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Soil Survey
of
Brown County, Nebraska

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Bureau of Chemistry and Soils

In cooperation with the
University of Nebraska State Soil Survey
Department of the Conservation and Survey Division

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CONTENTS

	Page
County surveyed	1
Climate	5
Agricultural history and statistics	6
Soil-survey methods and definitions	9
Soils and crops	11
Well-drained fine-textured soils of the uplands and terraces	13
Holt fine sandy loam	14
Ewing fine sandy loam	15
Marshall very fine sandy loam, sandy-substratum phase	16
Marshall fine sandy loam, sandy-substratum phase	17
Holdrege loam	18
Holdrege fine sandy loam	19
Hall very fine sandy loam	19
Well-drained moderately sandy soils of the uplands and terraces	20
Thurman fine sandy loam	21
O'Neill fine sandy loam, upland phase	22
O'Neill sandy loam	22
Well-drained sandy and incoherent soils of the uplands and terraces	23
Thurman loamy sand	24
Ewing loamy fine sand	25
O'Neill loamy fine sand, upland phase	25
Valentine loamy fine sand	26
Variably drained soils of the alluvial lands	27
Sarpy fine sand	28
Cass loam	28
Cass fine sandy loam	29
Cass fine sandy loam, heavy-subsoil phase	30
Cass loamy fine sand	31
Lamoure fine sandy loam	31
Poorly drained soils of depressions	32
Gannett loamy fine sand	33
Scott silty clay loam	33
Valentine-Gannett complex	34
Miscellaneous soils and land types	35
Dune sand	36
Valentine fine sand	36
Sparta sand	37
Rough broken land (Holt soil material)	37
Boyd clay loam	38
Land uses and agricultural methods	39
Classification of soil types according to productivity	42
Morphology and genesis of soils	44
Summary	48
Map.	

SOIL SURVEY OF BROWN COUNTY, NEBRASKA[1]

By E. A. NIESCHMIDT, Nebraska Soil Survey, in Charge, and S. R. BACON and F. A. HAYES, United States Department of Agriculture

COUNTY SURVEYED

Brown County is in the north-central part of Nebraska (fig. 1). Ainsworth, the county seat, is 230 miles in a direct line northwest of Omaha. The county is roughly rectangular, although its northern boundary, formed by Niobrara River, is somewhat irregular. Its width from east to west is 26 miles, and its length is about 48 miles. It comprises an area of 1,215 square miles, or 777,600 acres.

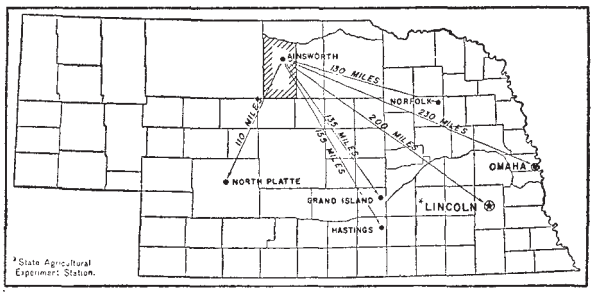


FIGURE 1.—Sketch map showing location of Brown County, Nebr.

This county is in the Great Plains region of the United States. It is part of a former nearly level to rolling constructional plain on which stream dissection and wind erosian have produced a somewhat pronounced relief. Within it are all or parts of four rather well-defined physiographic divisions, known as Niobrara Valley, Ainsworth table, Long Pine table, and the sand hills.

That part of the Niobrara Valley lying within the county varies in relief. It comprises the older and higher terrace remnants, the escarpment, and the alluvial lands immediately south of Niobrara River. The alluvial lands, of which those along that stream constitute only a small part, are described elsewhere in this section of the report.

The high terraces in Niobrara Valley formerly were one continuous terrace or bench, the approximate southern boundary of which can be seen on the accompanying soil map. This bench was formed before Niobrara River became so deeply entrenched, and it lies only a few feet below the general level of the uplands. It was subsequently dissected by tributaries to the trunk stream and covered by sandy water-laid deposits, the thickness of which over bedrock varies. In most places the sandy materials have been whipped by the wind to a low rolling or hummocky relief, but here and there nearly level areas remain where the former terrace surface persists. From the vicinity of Hazel Creek in Fairfield Precinct the high ter-

[1] Report written by F. A. Hayes.

races extend eastward in discontinuous strips, ranging from one-half mile to 2 miles in width, between the uplands and the escarpment which borders the bottom lands and low benches along Niobrara River. Their elevation above the present river channel ranges from 200 to 250 feet. They are much broader and smoother in Rock County to the east.

The escarpment, locally known as the Niobrara River breaks, is on both sides of the river. That part within Brown County includes a strip of steeply sloping or blufflike land which borders the southern edge of the valley floor. Here the river has cut through the sandy and gravelly rock mantle and the underlying light-colored and loosely indurated Tertiary beds, consisting of Ogallala sandstone in the upper part and Brule silts and clays in the lower part, and has developed its flood plain directly on the dark-blue Pierre shale of Cretaceous age.

The breaks range from less than one-eighth to about one-half mile in width. They are widest near the mouths of tributary creeks where erosion has cut narrow, in places almost vertical walled, canyons, some of which are more than 200 feet deep. The escarpment is shown on the accompanying soil map as rough broken land (Holt soil material). It is discontinuous and varies in height and steepness throughout the area of its occurrence across the county. In a few places, such as those west of Hazel Creek and east of Dutch Creek, wind-blown sand from surrounding areas has practically obliterated the escarpment. The greater part of the breaks is so gullied and steeply sloping as to be of little value even for grazing. In most places the cover is a rather dense growth of native trees. Similar strips of rough broken land extend back into the uplands for several miles along Fairfield, Plum, Dutch, Bone, and Long Pine Creeks.

Ainsworth table, the second physiographic division, occupies one of the less eroded remnants of the old constructional plain in the north-central and northeastern parts of the county and covers an area of about 230 square miles. It is bordered on the west and east by the deeply entrenched and severely eroded valleys of Plum and Long Pine Creeks, respectively; on the north by the Niobrara Valley; and on the south by the sand-hill section. This table rests on sand or on sandy bedrock. Its relief is generally smooth to strongly rolling, modified by numerous hummocks or hills of wind-blown sand and, in Bone Creek Valley northeast of Ainsworth, by rather broad strips of rough and broken land. The more nearly level tracts are near the southern edge of the table, mostly north of the Chicago & North Western Railway. Here the sandy deposits are smoothly mantled with a thin layer of wind-blown silt that has suffered little erosion. The silty areas are nearly level or very gently undulating except where they are traversed by tributaries to Plum, Bone, or Long Pine Creeks or where shallow basinlike depressions occur.

Long Pine table covers only about 10 square miles east of Long Pine Creek, but it is more extensively developed in Rock County. The surface features are similar to those of the Ainsworth table, but it is composed of slightly more sandy material. A small part of it is mantled with silt.

Approximately 80 percent of the county (the southern part) is a part of the main sand-hill section of Nebraska. Outliers of the sand

hills also occur as spurs, isolated hills, and ridges within each of the other three physiographic divisions. The gently undulating to hilly relief of the sand hills is the result of wind action on the incoherent sand. The sand has been piled into dunes and ridges, ranging from 30 to 70 feet in height, leaving intervening valleys, pockets, and swales, many of which are filled by ponds and marshes. The sand-hill section as a whole has a monotonously billowy to hilly landscape. Native grass covers practically all of it.

Alluvial land, including the flood plains and younger terraces, occupies only a small part of the county. It occurs as broken or continuous strips of various but generally narrow widths along most of the larger streams or as shallow poorly drained valleys throughout the sand hills wherever natural surface drainage is not entirely obstructed by dunes or ridges of sand. The flood plains lie from 2 to 8 feet above the normal level of the streams and are subject to inundation during periods of unusually high water. The most continuous strips are along Calamus River in the southern part of the county. The terraces lie from 10 to 50 feet above the streams, are not overflowed from the main channels, and are everywhere well drained. They occupy small bodies and narrow discontinuous strips along Plum, Bone, and Long Pine Creeks and larger bodies along Calamus River. The alluvial land along Niobrara River is of comparatively small extent.

The county as a whole is well drained. The water table is near or above the surface of the ground, however, in several of the enclosed valleys and pockets throughout the sand hills where it produces numerous wet hay flats, marshes, ponds, and lakes. Local patches of poorly drained land bordering most of the larger streams are subject to occasional overflow. In the northern part, drainage is effected to the north and east through Niobrara River and its tributaries. These streams flow swiftly and are actively deepening their channels. Drainage in the sand-hill section is mostly south and east through Calamus River and Goose Creek, which empty into North Loup River. Streams in the sand hills flow slowly and are aggrading their channels in places. The only land in the county which has been subjected to severe water erosion is on the breaks south of Niobrara River and on the valley slopes bordering the larger tributaries of that stream.

The main elevations recorded are along the Chicago & North Western Railway in the northern part of the county. The elevation of Long Pine is 2,403 feet above sea level; Ainsworth, 2,525 feet; and Johnstown, 2,604 feet.[2] The average elevations of the alluvial land and of the high terraces in the Niobrara Valley are 2,450 and 2,620 feet, respectively; that of Ainsworth table is 2,530 feet; that of Long Pine table is 2,325 feet; and that of the sand hills in the southern half of the county is 2,200 feet. The slope of the county, as a whole, is gradual to the south and east.

Well water of good but medium-hard quality is readily obtained throughout most sections. In places immediately south of Niobrara River on parts of the uplands and high terraces where the Pierre formation is either exposed or near the surface, however, the water

[2] GANNETT, H. A DICTIONARY OF ALTITUDES IN THE UNITED STATES. U. S. Geol. Survey Bull. 274, ed. 4, 1,072 pp. 1906.

supply is low and of poor quality. Wells on the Ainsworth and Long Pine tables range from 30 to 80 feet in depth, and those throughout the more elevated parts of the sand hills range from 40 to 90 feet. Good water is obtained within a depth of 30 feet in most of the valleys throughout the sand hills. A few artesian wells, ranging from 90 to 110 feet in depth, are in the southeastern part of the county. They penetrate sandy and gravelly beds where water is under pressure in the Pleistocene and Tertiary formations. Springs occur along most of the streams. In the Niobrara Valley the flow originates at or near the contact zone of the Pierre and Tertiary formations and for the most part is free, but elsewhere most of the springs seep rather slowly from water-filled sands.

The native vegetation is dominantly grasses, although rather dense stands of trees grow on the valley slopes and along the channel of Niobrara River and extend for several miles upstream along the tributaries of that river. Willow, cottonwood, bur oak, bull pine, hackberry, red cedar, basswood, elm, and ash are the dominant species. There are a few black walnut trees in the Niobrara Valley. The trees are used mainly for firewood and posts.

The native grasses in the more sandy parts of the uplands are largely reedgrass, bluestem, hairy grama, and *Redfieldia*. On the moderately sandy uplands, *Stipa*, or western needlegrass, junegrass, and blue grama prevail. Where not cultivated, the finer textured soils of the uplands support a less luxuriant growth of the same species as those that grow on moderately sandy land. In the lower lying situations as on the flood plains along streams and in numerous valleys and pockets throughout the sand hills, sloughgrass, panicgrass or switchgrass, big bluestem, and Indian grass are generally abundant.

Some of the earliest settlements within the area now included in Brown County were made by cattlemen who located in the Long Pine Creek Valley in 1879. The Fremont, Elkhorn, & Missouri Valley Railroad reached Long Pine in October 1881, and by the fall of 1882 nearly every quarter section (160 acres) of tillable land was either homesteaded, preempted, or taken as a timber claim.

The county was established and organized in 1883. When the bill to set aside territory for the organization of this county was introduced in the Nebraska Legislature, five members of that body bore the surname Brown, and it was therefore decided to use that name for the county which, at that time, included a much larger area than it does at present. Parts of it were taken in 1884 and 1888 to form Keya Paha and Rock Counties, respectively, leaving its boundaries as they now are.

The early settlers came mainly from eastern and southeastern Nebraska, although many were from States farther east. According to the records of the Federal census, the population has fluctuated considerably since 1890. During that year the county had 4,359 inhabitants. By 1900, following partition of the county and several years of drought and injury to crops by grasshoppers, the population had decreased to 3,470; in 1920 it was 6,749; and in 1930 it declined to 5,772. All is classed as rural, and the density is 4.7 persons a square mile. The composition of the population is 96.2 percent native white and the rest foreign-born white. Ainsworth, with

1,378 inhabitants, in the north-central part, is the county seat and largest town; Long Pine in the eastern part and Johnstown in the western part are smaller towns. These places supply local markets and distributing points for farm supplies and produce.

Transportation facilities are fair. The main line of the Chicago & North Western Railway, which extends from east to west across the northern part, furnishes good shipping connections for the towns through which it passes.

United States Highway No. 20 crosses the northern part of the county from east to west. It passes through Ainsworth, Long Pine, and Johnstown. Gravel-surfaced roads lead north from Ainsworth. Other roads are of earth construction, and the majority of those in the northern part of the county follow section lines except in the rougher areas where they conform to the relief. Most of them are kept in good repair. In the sand hills many roads are merely trails which follow valleys as far as possible. Travel between the valleys is laborious over almost constantly shifting sands. The more important sand-hill roads, especially the mail routes, cross fences through "auto gaps," but along most of the roads there are gates on all property lines.

The farm and ranch products, consisting chiefly of beef cattle, poultry, and poultry products, are sold either in the local towns or in outside markets. Cattle are shipped to Omaha.

Rural mail-delivery routes or star mail routes reach nearly all parts of the county. Telephones are on most of the farms in the northern part but are less common in the sand hills. The public-school system is well developed.

CLIMATE

The climate of Brown County is continental, with rather high summer and moderate to low winter temperatures. The springs are cool, with considerable precipitation, and the falls are long and pleasant, with only occasional rainy periods.

The precipitation varies greatly from year to year. According to the records of the United States Weather Bureau station at Ainsworth, about 73 percent of the mean annual precipitation of 25.23 inches falls during the principal part of the growing season—April to September, inclusive. In summer, most of the rain occurs as heavy thundershowers, but torrential rains are rare. Severe droughts seldom occur during May and June, but in July and August the rainfall varies considerably in amount and distribution and dry spells are common—some lasting for several weeks and causing greatly reduced crop yields. The annual snowfall ranges from a few inches to several feet and comes mainly during the period December to March, inclusive. The moisture received through this source, however, averages less than an inch a month during the winter.

The average date of the last killing frost is May 8 and that of the earliest is October 3, giving an average frost-free season of 148 days, which is ample for the maturing and harvesting of all crops common to this section. Killing frosts have been recorded, however, as late as May 27 and as early as September 15.

From about October 1 to April 1 the prevailing wind is from the northwest, and during the rest of the year it is from a southerly

direction. The average wind velocity is between 10 and 12 miles an hour. Strong winds are common, but tornadoes are rare. The relative humidity is about 70 percent.

Table 1, compiled from the records of the United States Weather Bureau station at Ainsworth, gives important climatic data which are considered fairly representative for the county as a whole.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Ainsworth, Brown County, Nebr.*

[Elevation, 2,521 feet]

Month	Temperature			Precipitation		
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1934)	Total amount for the wettest year (1915)
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*
December	24.6	70	−30	1.09	0.38	1.41
January	21.0	68	−30	.67	.11	1.68
February	25.3	71	−33	.92	.97	3.21
Winter	23.6	71	−33	2.68	1.46	6.30
March	34.6	80	−9	1.57	1.79	3.87
April	46.8	90	9	2.50	.21	4.08
May	56.4	99	21	4.16	1.18	5.00
Spring	45.9	99	−9	8.23	3.18	12.95
June	67.4	105	36	3.57	2.00	5.68
July	74.4	107	34	3.11	1.23	9.26
August	72.2	102	39	2.97	1.14	3.86
Summer	71.3	107	34	9.65	4.37	18.80
September	62.7	94	27	2.09	4.26	5.13
October	50.4	90	12	1.86	.27	2.15
November	36.3	83	−12	.72	.14	.15
Fall	49.8	94	−12	4.67	4.67	7.43
Year	47.7	107	−33	25.23	13.68	45.48

AGRICULTURAL HISTORY AND STATISTICS

Prior to 1875 the area now included in Brown County was inhabited chiefly by Indians, trappers, and hunters, who subsisted largely on wild game, fish, and fruit. The first settlers were cattlemen who were attracted to this section by the free open range with its luxuriant grass cover and abundant water supply. Cattle raising was the only agricultural pursuit until about 1879, when there was an influx of farmers who began to fence the arable land and break the continuity of the range. Within the next 3 years practically all the cultivable tracts had been acquired by homesteaders, and the cattlemen were forced to confine their operations to enclosed ranches in the rougher, sandier, and more poorly drained sections where cattle raising still is the chief occupation.

Few of the early farmers were acquainted with the local climatic and soil conditions. Many sandy areas which should have remained in pasture were broken and planted to corn, wheat, and oats. Yields from such areas were low, especially throughout the uplands where the crops were so greatly injured by drought and shifting sand that the returns scarcely warranted the expense and labor of harvesting.

Grain yields were also low or negligible in many of the sand-hill valleys where the soil is extremely fertile but where moisture conditions are favorable for cultivated crops during only a part of the year. In these localities the water table rises to or near the surface with such irregularity that production of grain is extremely hazardous except in a few places. Good yields of grain were obtained throughout the uplands only on the finer textured and more stable soils and in the lowlands only on the better drained soils. These phenomena led the settlers to confine farming operations to the more arable and comparatively inextensive soils, with the result that the production of grain has remained of secondary importance, compared with cattle raising and the production of native hay.

The Federal census reports $1,050,151 as the value of all crops and forest products produced in the county in 1929. Butter, cream, and whole milk were sold for $242,687, and poultry raised and eggs produced were valued at $180,674. The total value of all domestic animals on farms on April 1, 1930, was $1,819,047, of which cattle represented about 78 percent; horses, mules, asses, and burros about 14 percent; hogs about 8 percent; and sheep and goats less than 1 percent.

The Federal census reports 714,526 acres, or about 90 percent of the area of the county, included in farms in 1935. Land available for crops totaled 213,749 acres, or about 30 percent of the land in farms. Crops were harvested in that year, however, from only 116,714 acres. The rest of the land is used chiefly for the production of native pasture and hay. During most years corn occupies about 60 percent of the cultivated land. The acreage in oats is ordinarily about one-third and that in rye about one-sixth as large as that in corn. Other cultivated crops, including wheat, barley, potatoes, alfalfa, clover, and mixed clover and timothy, are grown on the better soils. With the exception of wheat, these crops are used mainly for feed or family use. None of them occupies more than 3 percent of the cultivated land in average years.

Table 2, compiled from Federal census data, gives the acreage devoted to the principal crops grown in the county in 1889, 1899, 1909, 1919, 1929, and 1934. These figures show the trend of agriculture.

TABLE 2.—*Acreage of principal crops in Brown County, Nebr., in stated years*

Crop	1889	1899	1909	1919	1929	1934 [1]
	Acres	*Acres*	*Acres*	*Acres*	*Acres*	*Acres*
Corn	18,107	27,082	32,485	38,519	44,981	1,019
Wheat (spring and winter)	6,883	4,083	3,930	12,121	2,009	205
Oats	4,412	892	15,439	8,051	15,191	200
Rye	1,363	117	3,370	8,787	7,657	2,775
Barley	837	28	294	135	715	----------
Potatoes	449	267	2,197	3,129	888	150
All hay	11,212	32,032	63,969	94,673	87,479	[2] 108,617
Wild hay	----------	28,583	59,517	85,455	76,895	[3] 103,069
Alfalfa	----------	----------	1,017	2,269	2,761	824
Timothy and clover alone and (or) mixed	----------	15	963	2,733	5,951	2,538
Other tame grasses	----------	2,885	2,202	3,017	1,263	[2] 1,429
Grains cut green	----------	549	270	782	601	757

[1] Acreage greatly reduced by drought.
[2] Includes sorghums for silage and fodder.
[3] Includes tame grasses.

Crop yields vary greatly from year to year, according to differences in the amount and distribution of the precipitation and in the length of the growing season. They also differ widely on the different soils, but over the county as a whole the average yields of the different crops over long periods are fairly uniform. Table 3, compiled from unpublished records of the Federal and State Departments of Agriculture, gives the proportion of land devoted to selected crops and average yields over the period 1923–34, inclusive.

TABLE 3.—*Land devoted to selected crops, and average acre yields for the 10-year period 1923–34, in Brown County, Nebr.*

Crop	Area of county occupied by crop in 1930	Average acre yield 1923–34	Crop	Area of county occupied by crop in 1930	Average acre yield 1923–34
	Percent	*Bushels*		*Percent*	*Bushels*
Corn	5.62	13.7	Barley	0.03	52.5
Oats	1.60	19.9			*Tons*
Rye	.83	9.9	Wild hay	[1] 10.44	[1] 0.63
Wheat (spring and winter)	.21	10.6	Alfalfa	[1] .27	[1] 2.00
Potatoes	.17	15.0	Range, pasture, and woodland	[1] 80.16	

[1] Average over period 1925-34.

The returns derived from livestock and livestock products are the chief sources of revenue. According to Federal census data, the value of cattle alone far exceeded that of all crops in 1929, and the total value of livestock and its products was more than twice as great as that of crops. Table 4, compiled from the Federal census reports, gives the number and value of domestic animals and poultry on farms and ranches in 1900, 1910, 1920, 1930, and 1935.

TABLE 4.—*Number and value of domestic animals and poultry on farms and ranches in Brown County, Nebr., in stated years*

	1900		1910		1920		1930		1935 [1]
	Number	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*	*Value*	*Number*
Cattle	21,515	$768,408	24,197	$543,894	28,696	$1,496,644	26,993	$1,416,009	27,645
Swine	10,297		8,492	81,607	14,897	280,111	10,975	155,234	3,879
Horses	3,988		7,020	585,644	7,341	383,815	5,450	216,582	5,416
Mules	181		361	34,463	508	40,102	481	24,875	185
Sheep	914		1,632	8,161	13,008	131,007	782	5,588	1,990
Poultry	30,352	6,915	38,825	16,328	56,928	46,100	[2] 51,689	[2] 39,284	40,221

[1] Value not reported.
[2] Chickens only.

Most of the farm dwellings are one-story wooden structures which are usually kept painted and in good repair. Only a few are equipped with modern conveniences. The barns and other outbuildings are generally large enough to house all the crops except the hay which is stacked in the field. The improvements average better on the larger cattle ranches throughout the sand hills and on the better farming soils north of the sand-hill section than elsewhere. According to the Nebraska agricultural statistics, 24 farm homes had modern heating plants, 76 had running water, 49 were equipped with

electricity, and 203 had radios in 1930. Most of the farms and ranches are fenced and cross fenced, mainly with barbed wire. The work animals include heavy draft horses and a few mules. Engine power is used to some extent in preparing the cultivable land for crops and in harvesting the hay. There were 110 tractors, 72 gas engines, 62 trucks, and 526 automobiles on the farms and ranches in 1930. The farm machinery is of the most modern and labor-saving types. On the better farming land, gang and sulky plows, disks, harrows, drills, listers, corn planters, binders, grain threshers, and the necessary equipment for harvesting hay are common. Throughout the sand hills many ranches are equipped with elaborate hay-harvesting machinery, including gang mowers, rakes, bucks, and balers. Only the more expensive farm machinery is sheltered.

Farm and ranch labor generally is plentiful, and it has been unusually cheap during the last few years. Monthly farm wages in 1932 ranged from $20 to $30 with board and lodging, day labor was plentiful at $1.25 or $1.50, and corn shuckers received from 3 to 5 cents a bushel for shucking corn. Only a few farmers hire help, but much labor is hired by the ranchers during the hay-harvesting season.

The Federal census reports 797 farms in the county in 1935, with an average size of 896.5 acres. The 210 farms and ranches, which included 1,000 acres or more, comprised almost 70 percent of the total land in farms.

In 1935 owners operated 52.2 percent of the farms, tenants 46.9 percent, and managers 0.9 percent. About 40 percent of the acreage in tenant farms rents for cash and 60 percent for a share of the products. Under the share method of land rental the owner receives one-third of the grain and hay, and all seed, labor, and machinery are furnished by the tenant. Under the cash system the tenant pays from $2 to $3 an acre for the better grade of farm land and from $80 to $100 a section (640 acres) for pasture land. Most tenants pay a lump sum for use of the pasture land and give a share of the crop for the hay land.

The selling price of individual farms ranges widely, depending on the character of the soil, relief, drainage, improvements, and location with respect to markets.

SOIL-SURVEY METHODS AND DEFINITIONS

Soil surveying consists of the examination, classification, and mapping of soils in the field.

The soils are examined systematically in many locations. Test pits are dug, borings are made, and exposures, such as those in road or railroad cuts, are studied. Each excavation exposes a series of distinct soil layers or horizons called, collectively, the soil profile. Each horizon of the soil, as well as the parent material beneath the soil, is studied in detail; and the color, structure, porosity, consistence, texture, and content of organic matter, roots, gravel, and stone are noted. The reaction of the soil [3] and its content of lime and salts are determined by simple tests. The drainage, both internal and external, and other external features, such as the relief, or lay of the

[3] The reaction of the soil is its degree of acidity or alkalinity expressed mathematically as the pH value. A pH value of 7 indicates precise neutrality; higher values indicate alkalinity, and lower values indicate acidity.

land, are taken into consideration, and the interrelation of soils and vegetation is studied.

The soils are classified according to their characteristics, both internal and external, special emphasis being given to those features influencing the adaptation of the land for the growing of crop plants, grasses, and trees. On the basis of these characteristics soils are grouped into mapping units. The three principal ones are (1) series, (2) type, and (3) phase. In places two or more of these principal units may be in such intimate or mixed pattern that they cannot be clearly shown separately on a map but must be mapped as (4) a complex. Areas of land, such as dune sand or bare rocky mountain sides, that have no true soil are called (5) miscellaneous land types.

The most important of these groups is the series, which includes soils having the same genetic horizons, similar in their important characteristics and arrangement in the soil profile, and developed from a particular type of parent material. Thus, the series includes soils having essentially the same color, structure, and other important internal characteristics and the same natural drainage conditions and range in relief. The texture of the upper part of the soil, including that commonly plowed, may vary within a series. The soil series are given names of places or geographic features near which they were first found. Thus, Holt, Marshall, Holdrege, and O'Neill are names of important soil series in this county.

Within a soil series are one or more soil types, defined according to the texture of the upper part of the soil. Thus, the name of the soil texture, such as sand, loamy sand, sandy loam, loam, silt loam, clay loam, silty clay loam, and clay, is added to the series name to give the complete name of the soil type. For example, Holdrege loam and Holdrege fine sandy loam are soil types within the Holdrege series. Except for the texture of the surface soil, these soil types have approximately the same internal and external characteristics. The soil type is the principal unit of mapping and, because of its specific character, is usually the soil unit to which agronomic data are definitely related.

A phase of a soil type is a subgroup of soils within the type, which differs from the type in some minor soil characteristic that may, nevertheless, have an important practical significance. Differences in relief, stoniness, and the degree of accelerated erosion frequently are shown as phases. For example, within the normal range of relief for a soil type, there may be parts which are adapted to the use of machinery and the growth of cultivated crops and other parts that are not. Even though there may be no important differences in the soil itself or in its capability for the growth of native vegetation throughout the range in relief, there may be important differences in respect to the growth of cultivated crops. In such an instance the more sloping parts of the soil type may be segregated on the map as a sloping or hilly phase. Similarly, soils having differences in stoniness may be mapped as phases, even though the differences are not reflected in the character of the soil or in the growth of native plants.

The soil surveyor makes a map of the county or area, showing the location of each of the soil types, phases, complexes, and miscella-

neous land types, in relation to roads, houses, streams, lakes, section and township lines, and other local cultural and natural features of the landscape.

SOILS AND CROPS

The more extensive soils have developed on wind- or water-worked sands or gravels of variable thickness. Fine-textured soils have developed from wind- or stream-deposited silts on the Ainsworth and Long Pine tables, and fine- to medium-textured soils have formed on bedrock on the slopes along Niobrara River and its larger tributaries. Over about 80 percent of the county, however, the soils are too sandy and unstable for cultivation. About 7 percent of the total area of the county is taken up by steeply sloping valley sides along the larger streams and depressions scattered throughout the uplands and bottom lands, in which the soils are nonarable because of unfavorable relief or drainage.

All the county is within or adjoins the sand-hill section of Nebraska, where grass is the dominant vegetation and where the stability and utilization of the more extensive soils depends largely on the maintenance of the native grass cover. Only the finer textured soils and those which are protected from blowing by a favorable relief or moisture supply can be used economically for cultivated crops. The preponderance of soils suited mainly for grazing and the production of wild hay has necessitated dependence on livestock, chiefly cattle, for revenue since the earliest settlements were made. Practically all of the arable land, including the well-drained fine-textured soils of areas topographically suited to cultivation and the more protected and stable soils of well-drained sandy areas, is used for the production of grain and tame hay. These crops are needed to supplement the native pasturage and hay and are fed on the farm or ranch where produced or are sold to local cattlemen. Some wheat is grown for ready cash, but this crop is of minor importance as a source of revenue.

The soils in the grazing and hay-producing areas are admirably suited, as a whole, to these purposes. Most of them are extremely sandy, low in organic matter, and light in color, but few are droughty. The fine sand of which they are so largely composed rapidly absorbs the comparatively light precipitation and allows little or no run-off. The absorbed moisture penetrates deeply, and loss through evaporation is reduced to a minimum. Light showers of one-half inch or less, which would be of practically no value to crops on the finer textured soil types, are markedly beneficial to the native grasses on the sandy soils. All the sandy soils are able to hold at least 7 inches of water within the rooting depth of the grasses, which is about 6 feet. Moisture even from infrequent heavy rains is retained by the sand until it can be utilized by the grasses during intervals between storms. Such favorable moisture conditions do not prevail on the finer textured cultivated soils which, owing to their slower absorbing powers, lose much of the precipitation through run-off even under the most careful management. During prolonged dry spells native grasses throughout the sand hills remain green much longer than any of the grain and wild- or tame-hay crops on the well-drained fine-textured soils.

The grassy vegetation, under which the soils of the county have developed, has produced an abundance of vegetable material, and all the soils not subject to abnormal wind or water erosion have accumulated large quantities of black decomposed organic matter in their topsoils. In moist situations, where the grass growth has been most luxuriant and decay has been comparatively rapid, the topsoils are almost black, regardless of their texture, to a depth ranging from 10 to 15 inches. The finer textured soils of the well-drained uplands have grayish-brown or dark grayish-brown topsoils which ordinarily extend to a depth ranging from 9 to 12 inches. On the more sandy uplands, excluding the sand hills proper, the topsoils are prevailingly grayish brown or light grayish brown and in few places exceed 6 inches in thickness. The darkness and thickness of the topsoil is everywhere dependent on the density and luxuriance of the grass cover during the development of the soil and on the length of time that the soil material has lain in its present position undisturbed by injurious erosion. On the sand hills, the grass cover, although well established in most places, is rather sparse and does not always prevent soil blowing. Conditions here are not favorable for the retention of decayed grass remains, so that the sands are darkened only to slight depths. Shallow light-colored soils also prevail on the steeper hill and valley slopes within areas of hard land. Much of the severely eroded land in the Niobrara River breaks has only a thin soil covering over bedrock, and in many places bedrock is exposed.

None of the soils in the county is acid. Several of them are low in lime, but all contain a sufficient quantity of this material for optimum plant growth. Lime is abundant in the finer textured soils which are not underlain at slight depths by sand. Zones of lime enrichment are present in the subsoils of the older and more nearly mature soils.

Except in small scattered areas where excessive moisture or the character of the parent material has promoted the development of heavy intractable subsoils, all the soils are sufficiently friable to facilitate easy root penetration and the free movement of moisture and air.

Although practically all of the arable soils are used for grain and tame-hay crops, only a few of them are suited to a wide variety or return high yields of these crops. Corn, which can adjust itself to a considerable range of soil and moisture conditions and which has a high feed value, is grown more extensively than any other cultivated crop. The highest yields of corn are obtained on some of the subirrigated soils in the bottom lands, good yields generally are obtained on the silty soils of the Ainsworth and Long Pine tables, and fair yields are obtained even on extremely sandy and rather unstable soils, provided they are adequately drained and contain a moderate supply of organic matter. The coarse roots of corn are less injured by drifting sand than are the finer roots of small grains.

Small grains are poorly adapted to most of the soils. They are grown chiefly on the finer textured, more stable, and better drained soils. Oats and rye, which are grown much more extensively than any other small grains, are produced mainly on the silt loam soils of the Ainsworth table. Much of the rye, however, is grown on rather sandy soils. Alfalfa is produced chiefly on the finer textured soils of the terraces and the better drained soils of the bottom lands. It does best in situations where the moisture supply is supplemented by run-

off from higher levels or where the water table lies between 5 and 20 feet below the surface.

On the bases of drainage, texture, crop adaptations, and other characteristics of the soil or its environment, which are especially related to agriculture, the individual soils of the county are placed in six groups as follows: Well-drained fine-textured soils of the uplands and terraces, well-drained moderately sandy soils of the uplands and terraces, well-drained sandy and incoherent soils of the uplands and terraces, variably drained soils of the alluvial lands, poorly drained soils of depressions, and miscellaneous soils and land types.

This grouping does not imply that the agricultural practices are strictly uniform on the soils of any particular group or that the soils of each group are equally productive. The farming systems and the crops grown may vary widely on the different soils within a group or even on the same soil in different localities, according to differences in the requirements of the individual farmer. The yields also may vary on the same and on different soils within a group, in accordance with local variations in relief and in the amount and distribution of the precipitation. Over a period of years, however, the soils of each group named give the largest returns from, and are used chiefly for, the crop or crops best suited to their moisture supply, texture, coherence, and other profile features. None of the soil groups is confined to any particular part of the county, but many small areas of soils in each group occur within larger areas of soils of other groups.

In the following pages the various soils of the different groups are described, and their crop adaptations are discussed in detail; the accompanying soil map shows their distribution; and table 5 gives their acreage and proportionate extent.

TABLE 5.—*Acreage and proportionate extent of the soils mapped in Brown County, Nebr.*

Soil type	Acres	Per-cent	Soil type	Acres	Per-cent
Holt fine sandy loam	2,112	0.3	Sarpy fine sand	4,800	0.6
Ewing fine sandy loam	7,168	.9	Cass loam	3,264	.4
Marshall very fine sandy loam, sandy-substratum phase	7,296	.9	Cass fine sandy loam	11,648	1.5
Marshall fine sandy loam, sandy-substratum phase	3,712	.5	Cass fine sandy loam, heavy-subsoil phase	4,736	.6
Holdrege loam	22,400	2.9	Cass loamy fine sand	11,456	1.5
Holdrege fine sandy loam	3,712	.5	Lamoure fine sandy loam	768	.1
Hall very fine sandy loam	832	.1	Gannett loamy fine sand	8,448	1.1
Thurman fine sandy loam	12,544	1.6	Scott silty clay loam	256	.1
O'Neill fine sandy loam, upland phase	2,880	.4	Valentine-Gannett complex	2,304	.3
O'Neill sandy loam	6,016	.8	Dune sand	412,608	53.0
Thurman loamy sand	16,512	2.1	Valentine fine sand	165,376	21.3
Ewing loamy fine sand	4,032	.5	Sparta sand	3,456	.4
O'Neill loamy fine sand, upland phase	6,336	.8	Rough broken land (Holt soil material)	29,696	3.8
Valentine loamy fine sand	22,784	2.9	Boyd clay loam	448	.1
			Total	777,600	

WELL-DRAINED FINE-TEXTURED SOILS OF THE UPLANDS AND TERRACES

The soils of this group occupy 6.1 percent of the total area of the county. They are suited to a wider variety of crops than are the soils of any other group. The greater part of most of them is under cultivation. They include Holt fine sandy loam, Holdrege loam, Holdrege fine sandy loam, Hall very fine sandy loam, Ewing fine

sandy loam, and the sandy-substratum phases of Marshall very fine sandy loam and Marshall fine sandy loam. The relief, as a whole, ranges from very gently undulating to rather steeply sloping. Drainage is very good, and erosion is severe only on parts of Holt fine sandy loam. All these soils, except the Hall soil which occurs on terraces, occupy upland positions, chiefly north of the Chicago & North Western Railway.

With few exceptions, the soils belonging to this group have accumulated large quantities of organic matter. Most of them have darker and thicker topsoils than any other well-drained soil. Moreover, their topsoils are sufficiently fine textured to be very coherent and not subject to excessive wind erosion, provided reasonable care is taken in managing the land. The subsoil of the Holt soil is moderately sandy, whereas that of the Ewing soil consists mainly of mixed clay and sand in the upper part and of sand in the lower part. The Marshall, Holdrege, and Hall soils have silty subsoils, but in this county they rest on a sandy substratum within a depth of 6 feet in most places. The Marshall and Ewing soils, although not deficient in lime, are the only soils which do not contain an abundance of this material.

Except in small, steeply sloping areas, the soils of this group are among the most productive in the county for grain crops. Average yields of corn are not so high as on some of the better drained soils of the bottom lands, which have a greater moisture supply, but yields of oats, rye, and barley, over a period of years, are seldom exceeded on any soil of other groups. The moisture supply is not sufficient, however, on the well-drained uplands and terraces to insure optimum yields except in the most favorable years. Alfalfa does well on the Hall soil and fairly well on the Ewing soil.

Holt fine sandy loam.—The topsoil of Holt fine sandy loam, which is friable throughout, ranges in thickness from about 8 to 12 inches, contains an abundance of well-decomposed grass remains, and is very dark grayish brown. Its texture varies from loamy fine sand to very fine sandy loam, but, as the soil occupies such a small total area and as most of it is, or closely approaches, a fine sandy loam, it is classed under that texture on the accompanying soil map. The subsoil consists largely of fine sand or medium sand, but it contains enough silt and clay to make it moderately coherent. It is dark grayish brown in the upper part, where it is stained by organic matter washed down from the topsoil and is light grayish brown or almost white below this. Lime is abundant, especially in the lower part, where the light color is due mainly to the presence of lime. At a depth ranging from about 18 to 36 inches, the subsoil rests on partly weathered sandstone of the Ogallala formation, and scattered fragments of this sandstone may occur in any part of the soil profile. The soil is shallowest, that is, the bedrock proper lies nearest the surface of the ground, in the more steeply sloping situations.

Holt fine sandy loam is well drained throughout. The gradient is sufficient to insure adequate surface run-off, and the soil material is porous enough to allow good underdrainage. Erosion is severe only on steep slopes.

Numerous small areas of this soil are scattered throughout the uplands in the northern and northeastern parts of the county, mostly

in Pine Glen and Garfield Precincts. The largest area (about 750 acres) is in the northeastern part of Garfield Precinct, 2 miles south of Niobrara River. Few of the remaining areas include more than 160 acres each or occupy more than a small part of any one farm.

Most areas of this soil are nearly level or gently undulating, but some occupy fairly steep slopes. Practically all the land is topographically suited to cultivation. The soil has developed from slightly indurated light-colored limy beds of Ogallala sandstone which is the uppermost bedrock of the region, but in most places the sandstone is either so deeply buried by later deposits of loess or sand or is characterized by such rough, broken, and severely eroded relief that little or no soil has formed on it. Even in localities where the bedrock has been exposed for long periods under topographic conditions favorable for deep soil development, most of the soil is shallow, and bedrock lies within 3 feet of the surface.

Throughout most areas of Holt fine sandy loam the soil is sufficiently coherent to resist destructive erosion by wind, provided reasonable care is taken in its management. In areas where the topsoil has a loamy fine sand texture, the soil is rather unstable, and, unless these areas are in protected situations, they are used for native pasture and hay land. Elsewhere the land is well adapted to most of the crops commonly grown. About 80 percent of the land is under cultivation. Corn, oats, and rye, ranking in acreage in the order named, are the leading crops.

This soil has high water-holding capacity and absorbs moisture rapidly. During seasons of normal precipitation it is nearly as productive of corn and rye as any of the less sandy soils of the well-drained uplands, and, in dry seasons, is more productive. Most of it is a little too sandy for the highest yields of oats, although it is fairly well suited to that crop. The average acre yield of corn over a period of years is about 15 bushels, oats 15 bushels, rye 9 bushels, and wheat 7.5 bushels. Sweetclover yields about four-fifths of a ton of hay an acre, and alfalfa yields a somewhat larger quantity. The latter crop is usually cut three times during the growing season. It is seldom grown on the Holt soil, however, on account of the difficulty in obtaining a satisfactory stand in the rather loose and sandy seedbed.

Ewing fine sandy loam.—The topsoil of Ewing fine sandy loam, which is well supplied with organic matter, is very dark friable fine sandy loam ranging from 10 to 14 inches in thickness. The topmost 3 or 4 inches of material is ordinarily a little more sandy and slightly less coherent than the material below, but the topsoil, as a whole, has sufficient body to prevent destructive soil drifting. The soil is not subject to injurious water erosion. Beneath the topsoil the material changes abruptly to grayish-brown moderately heavy clay loam or silty clay loam which, in its upper part, is hard and tough when dry and sticky and plastic when wet, but which becomes friable and slightly light colored in its lower 4 or 5 inches. At an average depth of about 30 inches there is an abrupt change to incoherent fine gray sand or a mixture of sand and small pebbles. The reaction of both the topsoil and the subsoil is about neutral.

This soil occupies many small areas on the Ainsworth table and the surrounding sandy lands, principally in Buffalo, Ainsworth, and

Johnstown Precincts, and a few small areas in the sand hills. Few exceed 200 acres in size, and most of them are much smaller. One of the largest, comprising about 800 acres, is 2 miles northwest of Long Pine around the head of a tributary to Willow Creek. Another large area is 1 mile east of Johnstown.

Most of this land is nearly level or slightly depressed so that considerable moisture is received through seepage and run-off from higher levels. Surface drainage channels are not established, but underdrainage is adequate, considering the moisture supply in this section, and none of the soil is too wet for the production of grain crops.

This soil has a high water-holding capacity. Its topsoil absorbs moisture rapidly and the heavy layer in the subsoil greatly retards loss of moisture through seepage. Approximately 90 percent of the land is cultivated. All crops common to the section do well, but corn is the most extensively grown crop. Average yields are a little lower than on most of the other soils of this group but are higher than those on any well-drained soil of the uplands not belonging to the group. Corn yields about 15 bushels an acre, oats about 12½ bushels, rye about 7½ bushels, and wheat about 6½ bushels. Alfalfa is of minor importance on this soil, but it is grown more extensively than on any other upland soil. During average years alfalfa yields about nine-tenths of a ton of hay an acre. Yields of sweetclover hay are about the same as those of alfalfa or somewhat lower.

Although well suited for grain and tame-hay crops, Ewing fine sandy loam is not sufficiently extensive to be of more than local agricultural importance in this county. Areas too small or too inconveniently located to warrant cultivation are used for native pasture and hay land. The grasses on them will support a cow or steer on each 6 acres during the summer grazing season or, when cut for hay, will yield about two-thirds of a ton an acre.

Marshall very fine sandy loam, sandy-substratum phase.—There is no typical Marshall soil in Brown County. On the Ainsworth and Long Pine tables, however, are numerous small areas in which the soil more nearly resembles soils of the Marshall series than it does any other soil in the State. It has developed on loess as has true Marshall soil, but the loess is much thinner and is somewhat sandier than that underlying the Marshall soils in eastern Nebraska and western Iowa. Throughout nearly all of its distribution in this county the loess rests on incoherent sand or mixtures of sand and gravel within a depth of 6 feet. In many places it is covered by wind-blown sandy deposits ranging from 6 to 15 inches in thickness. On these shallow and comparatively sandy loessial areas, the soils, if low in lime, are classed in this survey as sandy-substratum phases of the typical Marshall soils which they most closely resemble.

The topsoil, which ranges in thickness from 12 to 20 inches, contains an abundance of organic matter and is very dark grayish brown. The texture varies from loam to very fine sandy loam, the latter predominating. The topsoil merges downward with a more brown and slightly finer textured material which becomes increasingly lighter colored and silty with depth. It is very light grayish-brown almost pure silt below a depth of about 40 inches. The silty subsoil

gives way abruptly at a depth of about 4 feet to a loose sand or sand and gravel substratum which extends to a depth of many feet.

The sandy-substratum phase of Marshall very fine sandy loam is chiefly in Pine, Buffalo, and Ainsworth Precincts, where it occupies numerous nearly level or gently undulating areas on the thinly loess mantled uplands. The largest body, comprising about 1,600 acres, is in the vicinity of Ainsworth. Few of the remaining areas exceed 160 acres in size, and the total extent of this soil is small. Surface drainage and underdrainage are good, and none of the soil is subject to severe wind or water erosion.

The principal variations in this soil are in the thickness and texture of the topsoil and in the depth to the coarse-textured substratum. The latter is reached, in places, within a depth of 3 feet from the surface of the ground, but nowhere is it lower than 6 feet.

The sandy-substratum phase of Marshall very fine sandy loam includes some of the most valuable farming land in the county. It is friable throughout, has high moisture-holding powers, and is well suited for any grain crop adapted to the temperature of this section. It is used most extensively for the production of corn and oats. Yields of these crops, although about as high as any obtained on the best well-drained soils in this county, are considerably lower than those on typical Marshall soils farther east in sections where the precipitation is higher. The average acre yield of corn is about 22½ bushels, oats about the same as corn, and wheat and rye 11 bushels. Alfalfa occupies only a few small fields. It yields about nine-tenths of a ton of hay an acre in seasons of normal precipitation.

Marshall fine sandy loam, sandy-substratum phase. — The sandy-substratum phase of Marshall fine sandy loam has developed from the same general type of parent material as has the corresponding phase of Marshall very fine sandy loam, but it lies nearer areas of dune sand and sandy Valentine soils and has received more and coarser wind-blown sand in its surface layer. Its general distribution and position are about the same as those of the sandy-substratum phase of Marshall very fine sandy loam, but it is less extensive.

The topsoil of Marshall fine sandy loam, sandy-substratum phase, which averages about 13 inches thick, is very dark grayish-brown friable fine sandy loam or sandy loam, the former texture predominating. The upper part of the subsoil has about the same texture and consistence as the topsoil, but it is slightly lighter colored and more brown. The subsoil merges, at a depth of about 30 inches, into light grayish-brown or yellowish-brown friable silt which in most places is about 2½ feet thick and gives way abruptly to incoherent gray sand or sand and gravel. Although the soil is not limy, crops do not indicate a deficiency of lime.

Most of this soil is on the Ainsworth table, where it occupies several nearly level or undulating areas, few of which exceed 160 acres in size. None of it has been injured by water erosion, and, where carefully managed, it is not subject to destructive wind erosion even under cultivation. It absorbs moisture rapidly, and both surface drainage and underdrainage are good.

Practically all of this soil is used for the production of corn and oats, in the proportion of about 8 acres of the former to 1 of the latter during average years. There are a few small fields of rye and wheat. Over a period of years, corn yields about 20 bushels an acre, oats about 17½ bushels, rye about 10 bushels, and wheat about 9 bushels.

The topsoil can be cultivated under a wide range of moisture conditions without injuring its tilth. During prolonged dry and windy spells it has a slight tendency to blow, but this can be controlled largely by leaving some sort of vegetative cover on the land during dry periods. The topsoil can be plowed almost immediately after rains without clodding or baking.

Holdrege loam.—The topsoil of Holdrege loam is very dark grayish-brown mellow loam or very fine sandy loam, about 18 inches thick, containing a large quantity of organic matter. It gives way gradually to a slightly heavier but friable upper subsoil layer composed largely of silt loam that continues to an average depth of about 30 inches. In places the material is slightly lighter colored, and in others it is darker than the material in the topsoil. It merges downward into very light grayish-brown or grayish-yellow loose silt of the modified loess deposit from which the soil has developed. Lime, chiefly in finely divided form, is abundant below a depth of about 40 inches. The silt rests abruptly on incoherent sand or sand and gravel below a depth ranging from 4 to 5 feet.

Holdrege loam is the most extensive soil developed on loess in this county. It occupies large and small areas on the more nearly level-lying parts of Ainsworth table and small areas on the Long Pine table. One of the largest and most typical bodies covers an area of about 8 square miles in the northern part of Buffalo Precinct. Other large developments are northwest of Ainsworth and northeast of Johnstown. This soil has good surface drainage and underdrainage, and it is not subject to destructive wind or water erosion. It resembles the sandy-substratum phase of Marshall very fine sandy loam in many respects, but, as a whole, it contains less sand and much more lime.

Holdrege loam is well adapted to any of the crops commonly grown, and practically all of it is cultivated. Owing to its fine-textured topsoil, it absorbs moisture a little more slowly than the other soils formed from loess, and it is slightly more droughty during prolonged dry spells. Its moisture-holding capacity is unusually high, however, and, during seasons of normal precipitation, crop yields on this soil are not exceeded by those on any upland soil not favored by run-off from higher levels. The large extent of this soil compared with other fine-textured soils causes it to rank as the most important soil in the county for the production of grain. As on all arable land in the county, corn is the leading crop, but this soil is about equally well suited to oats, rye, wheat, and barley. Crop yields vary considerably from year to year, depending on the amount and distribution of the precipitation, but complete crop failures are seldom experienced. Average yields of corn and oats are about 22½ bushels an acre, of wheat and rye, about 11 bushels, and of barley about 16 bushels.

Holdrege fine sandy loam.—Holdrege fine sandy loam is associated with, but is much less extensive than, Holdrege loam, from which it differs mainly in having a little more and coarser sand in its topsoil, owing to its proximity to dune sand and the sandy Valentine soils. The topsoil, which averages about 17 inches thick, is dark grayish-brown mellow fine sandy loam well supplied with organic matter. It does not, however, contain so much organic matter and is, therefore, not quite so dark as the corresponding layer of Holdrege loam. The upper part of the subsoil consists largely of silt and is noticeably heavier than the topsoil, but it is friable throughout and is easily penetrated by moisture, air, and plant roots. In places it is either slightly lighter or darker than the overlying horizon. The lower part of the subsoil is very light grayish-brown or grayish-yellow friable silt with a high lime content. It begins at an average depth of about 35 inches and is abruptly underlain, at a depth ranging from 4 to 6 feet, by the coarse-textured substratum similar to that underlying Holdrege loam. This soil occupies several bodies on the smoother parts of the Ainsworth table, the largest of which covers about 800 acres northeast of Johnstown. Few of the other bodies occupy more than 160 acres each.

Like Holdrege loam, this soil has developed on a thin loessial deposit and rests on incoherent sand or sand and gravel within a depth of 6 feet. It also resembles the sandy-substratum phase of Marshall fine sandy loam in most respects, but it has much more lime in its subsoil. Surface drainage and underdrainage are good. The soil is not subject to abnormal water erosion, nor is it greatly injured by wind erosion under cultivation, provided reasonable care is taken to maintain a vegetative cover on the land during a large part of the year. Moisture is absorbed rapidly and retained well.

Practically all of this land is under cultivation. Corn is the chief crop, followed by oats, rye, and barley, ranking in acreage in the order named. During dry years corn yields are about 5 percent higher on this soil than on Holdrege loam, but in seasons of normal precipitation the fine sandy loam is not so productive of corn as is the loam. Small grains yield slightly less than on Holdrege loam, mainly because the surface layer is somewhat too loose and unstable for optimum yields of these crops.

Owing to its small extent, this soil is of only local agricultural importance in this county.

Hall very fine sandy loam.—Hall very fine sandy loam has developed on silty or slightly sandy alluvium deposited originally on the flood plains of streams. Subsequent stream entrenchment has left these deposits as nearly level or gently undulating terraces and benches, which now lie from 10 to 20 feet above the bottom lands.

The topsoil, which extends to an average depth of 19 inches, contains an abundance of organic matter and is very dark grayish brown and friable throughout. Its texture varies widely but is very fine sandy loam in most places. The topsoil is underlain by a slightly lighter colored and heavier, although friable, layer composed mainly of silty clay loam which grades into very light grayish-brown floury limy silt similar to that underlying the Holdrege soils of the uplands. Incoherent gray sand or sand and gravel is present below a depth of 50 inches.

Two small bodies southwest of Ainsworth, with a combined area of about 90 acres, have a topsoil of sandy loam, and a sandy loam or loamy fine sand topsoil prevails over most of a body, including an area of about 100 acres, northwest of this town. Aside from their coarser textured surface layers the soil in these bodies does not differ materially from the typical soil, therefore they have not been shown separately on the soil map.

This soil occupies only a few small areas on second bottoms, mostly along Bone Creek and its tributaries. The largest body, including about 320 acres, is north of Ainsworth. The soil closely resembles Holdrege very fine sandy loam, but its lower position causes it to receive more moisture than that soil, through run-off and seepage from higher levels. Surface drainage and underdrainage are good, and the moisture-holding capacity is high. The soil is not subject to abnormal wind or water erosion.

This is a very productive soil, and practically all of it is cultivated. All crops common to the section do well. All grains and tame hay yield as high as or higher than they do even on the better drained parts of the bottom lands where moisture is more abundant. Corn and oats yield 27½ bushels an acre, wheat and rye 14 bushels, barley 20 bushels, alfalfa 2¼ tons, and sweetclover 1⅙ tons.

WELL-DRAINED MODERATELY SANDY SOILS OF THE UPLANDS AND TERRACES

The soils of this group are a little too sandy for satisfactory yields of most small-grain crops, but they are fairly productive of corn. They include Thurman fine sandy loam and O'Neill fine sandy loam, upland phase, on the gently rolling uplands and O'Neill sandy loam on the nearly level or undulating terraces. All these soils are well drained, but none is subject to destructive water erosion. Their virgin topsoils range from 7 to 12 inches in thickness and are almost as dark as those of the well-drained fine-textured soils previously described. Although rather sandy, they contain an abundance of organic matter and fine mineral materials, and they are not injured by wind erosion so long as the grass cover remains intact. The subsoils consist largely of incoherent gray sand which, in the upland phase of the O'Neill soil, is mixed with more or less gravel. These soils are low in lime, although crops grown on them do not indicate a deficiency in this material. The high sand content allows practically no run-off. Nearly all of the precipitation that falls is absorbed and, except where the soil is very gravelly, is held until it is taken by the vegetation.

The chief disadvantage in using these soils for cultivated crops is the care required to check soil blowing when the protective grass cover is destroyed. After a few years of tillage the topsoils become noticeably lighter in color and thinner than they were in the virgin condition. In poorly managed fields the soils have already lost so much of their former organic and fine mineral constituents and have become so unstable that they are of little value for grain crops. Under careful management they can be used profitably for the production of corn, rye, and sweetclover. Some oats and barley are grown on them, but yields are low during most years. Practically no wheat is produced.

Although fairly well suited for growing corn, rye, and sweetclover, the soils of this group are so subject to wind erosion when broken for crops that less than 50 percent of their total area is under cultivation. Corn occupies about 70 percent of the tilled acreage, rye about 20 percent, and the remainder is used mainly for oats, barley, and sweetclover. During prolonged droughts, the grain and tame-hay yields on these soils are higher than they are on the finer textured soils of the uplands, provided the velocity of the wind is not sufficient to cause excessive drifting of sand. In seasons of normal and of high precipitation, however, cultivated crops yield less on the sandy soils.

All uncultivated areas included with this soil group retain their cover of grasses and are used for native pasture and hay land.

Thurman fine sandy loam.—The 7- to 12-inch topsoil of Thurman fine sandy loam is dark grayish brown or very dark grayish brown, owing to the presence of well-decomposed organic matter. It consists largely of sand, but the large content of organic material and a moderate content of silt and clay give it a fine sandy loam texture. The upper part of the subsoil is light-brown or grayish-brown moderately coherent loamy fine sand which grades, at a depth of about 20 inches, into incoherent gray sand containing a few small pebbles.

This soil occupies areas on and around the edges of the Ainsworth and Long Pine tables in the north-central and northeastern parts of the county. One of the largest bodies, comprising about 4 square miles, is along the Rock County line east of Long Pine. The numerous other areas are much smaller, many of them including less than 160 acres each.

This soil has developed on sands which were carried from the west by streams and deposited on outwash plains along the ice front at a time when glaciers covered all of what is now eastern Nebraska. The relief ranges from nearly level to gently rolling and is most pronounced in areas where wind has slightly modified the plainlike surface subsequent to deposition of the sand. Surface drainage channels are few and poorly established because most of the precipitation is rapidly absorbed by the soil material. The content of lime is not sufficient in any part of the soil profile to effervesce when acid is applied, but neither the native grasses nor cultivated crops indicate a deficiency in lime.

Nearly all of the light rainfall is absorbed and held by the soil within the rooting depth of plants, until it is drawn out by the vegetation. In dry years this soil is more productive, especially of corn, than any of the finer textured soils of the well-drained uplands. In seasons of normal precipitation, however, it returns lower yields of corn than the more silty soils. Yields of small grains are lower in nearly all years than on the heavier soils, mainly because the topsoil forms a loose seedbed and is subject to slight drifting, both which characteristics are detrimental to small grains.

About 60 percent of the land is devoted to cultivated crops, principally corn. Rye, sweetclover, and barley do fairly well and occupy many small fields. Very little oats and practically no wheat are produced. Yields vary widely in different seasons. Corn and barley average about 12½ bushels an acre, rye about 6 bushels, and sweetclover about seven-tenths of a ton of hay.

The uncultivated areas retain their native cover of grasses which will support a cow or steer on each 6½ acres during the summer grazing season or will yield about one-half ton of hay an acre.

O'Neill fine sandy loam, upland phase.—The upland phase of O'Neill fine sandy loam differs from O'Neill sandy loam in that it has less and slightly finer sand in its topsoil and more gravel in its subsoil. It occurs on the uplands rather than on the terraces.

The 8- to 10-inch topsoil is friable fine sand or medium sand, containing enough silt and clay to make it moderately coherent and give it, in most places, a fine sandy loam texture. It also contains enough organic matter to impart a very dark grayish-brown color. In a few areas, too small to warrant separation on the soil map, silt and clay are more abundant and the sand is somewhat finer than is typical so that the topsoil has a very fine sandy loam texture. The upper layer of the subsoil is slightly lighter colored and finer textured than the surface soil. It consists of dark grayish-brown heavy fine sandy loam or light sandy clay loam. This layer does not exceed 12 inches in thickness and in places is much thinner. It grades into an incoherent coarse sand which becomes increasingly gravelly with depth. The soil is very low in lime, but no part of it gives an acid reaction.

Several bodies of this soil are widely scattered on, and around the margins of, the Ainsworth and Long Pine tables. The largest area is 1½ miles northwest of Long Pine and covers about 500 acres. Most of the bodies comprise less than 160 acres each. This is not an extensive soil.

This soil has developed on a mixture of sand and gravel that was deposited in its present position as outwash from the west during glacial times. Subsequent accumulations of organic matter and wind-blown silt and clay have reduced the coarseness of the surface layer in the outwash material.

The relief ranges from nearly level to gently undulating. All the areas are well drained. Surface drainage channels are poorly developed, as a rule, because practically all of the surplus surface moisture is rapidly absorbed by the sandy soil material. The surface layer is sufficiently stable for cultivation, provided reasonable care is taken to curtail wind erosion. The uppermost 15 inches of the soil is highly retentive of moisture. The rest of the profile, however, is too coarse to hold moisture well, and the soil, as a whole, is rather droughty except in seasons of normal or heavy rainfall.

Only about 60 percent of this land is under cultivation. Corn occupies by far the greater part of the tilled acreage, and there are a few small widely scattered fields of other crops, chiefly rye and sweetclover. Yields are about 5 percent lower than those obtained on Thurman fine sandy loam. The uncultivated areas are used mainly for pasture and hay. They support a fair growth of tall grasses, chiefly big and little bluestems, which will support a cow and calf on about 9 acres during the grazing season, May to October, inclusive, or will yield about one-half ton of hay an acre.

O'Neill sandy loam.—The 8- to 10-inch topsoil of O'Neill sandy loam, which is well supplied with organic matter, consists of very dark grayish-brown loose friable sandy loam or loamy fine sand, the former texture predominating. It is underlain by a 6- to 8-inch layer of somewhat lighter colored, much more sandy, and less coherent

loamy sand or loamy fine sand. This lower layer merges downward into grayish-brown fine to coarse incoherent sand that continues to a depth exceeding 10 feet. In places the sand contains a small quantity of gravel, but pebbles are nowhere so abundant as in the subsoil and substratum of the upland phases of the O'Neill soils.

O'Neill sandy loam is not very extensive. It occupies narrow strips on sandy terraces lying from 12 to 30 feet above the bottom lands in a few stream valleys throughout the northern part of the county. The largest area comprises about 650 acres on the east side of Plum Creek in Johnstown Precinct. Few of the other bodies include more than 80 acres each.

The relief, in most places, is nearly level or very gently undulating. In small patches the sand, of which this soil is so largely composed, has been whipped by the wind into low knobs and ridges, which, however, do not exceed 4 feet in height. Surface drainage channels are not developed, but the precipitation is absorbed so rapidly that all the land is well drained. None of the soil is subject to abnormal water erosion. The reaction is about neutral, and the soil seems to contain enough lime for crop needs.

About 70 percent of this land is under cultivation. The soil is not so well suited to small grains as is the finer textured Hall soil, but oats and rye do fairly well. Corn is the leading crop, partly because of its high feed value and partly because it can be planted deeper than small grains and is less injured by drifting sand. Sweetclover and alfalfa do well in most years, although the latter crop is rather difficult to establish on account of the rather loose seedbed. During dry periods the corn yields are exceeded only by those obtained on the better drained soils of the bottom lands. In seasons of normal precipitation, however, this soil is less productive of corn than any of the finer textured soils of the uplands and terraces. Over a period of years corn will average about 15 bushels an acre, oats about 12½ bushels, and rye about 7½ bushels. Sweetclover yields about nine-tenths of a ton of hay an acre during most years.

The native grasses on virgin areas of this soil will support a cow or steer on about 6 acres during the 6-months' grazing season or will produce a little over one-half ton of hay an acre.

WELL-DRAINED SANDY AND INCOHERENT SOILS OF THE UPLANDS AND TERRACES

The soils of this group are unstable when not covered by vegetation, and, as a whole, they are rather poorly suited to cultivated crops except in situations protected against wind erosion. The group comprises Thurman loamy sand, the loamy fine sand types of the Valentine and Ewing soils, and the upland phase of O'Neill loamy fine sand. All are on the uplands. The relief, in general, ranges from nearly level to gently undulating, but it is rolling to hummocky in situations where wind action has been especially severe.

The topsoils average about 8 inches in thickness, are very sandy, but have accumulated enough organic matter to impart a loamy texture, and, to the virgin soil, a dark color. The content of organic matter and intensity of darkness, however, rapidly decrease under cultivation except in places protected from soil drifting. Aside from Ewing loamy fine sand, which contains considerable silt and more or

less clay in the upper part of its subsoil, all soils of this group have incoherent sand subsoils. The substrata invariably consist of loose sand or a mixture of sand and gravel.

None of these soils shows an alkaline reaction, but all contain enough lime for crop needs.

Although these sandy soils are rather poorly suited to cultivated crops, they are not especially droughty. They all, if carefully managed to retard blowing, will give higher returns from corn and rye than when used for native hay or pasture land. Most of them are surrounded by areas of dune sand and Valentine fine sand, which are used for the production of wild grasses. On many ranches the soils belonging to this group are the only ones that will produce grain feed. It is estimated that less than 30 percent of the area occupied by them is under cultivation. Yields of corn and rye are considerably lower than those obtained on soils of the groups previously described.

Thurman loamy sand.—Thurman loamy sand differs from Thurman fine sandy loam of the group of well-drained moderately sandy soils mainly in that it has more and coarser sand in its topsoil and is less stable against wind erosion. The virgin topsoil is incoherent loamy sand containing sufficient organic matter to make it very dark grayish brown when moist and only slightly lighter in color when dry. In most cultivated fields, part of the organic material has been removed by the wind, and the topsoil, although still fairly dark, has a noticeably lighter color than that in virgin areas. The rest of the soil profile is incoherent sand of fine or medium grades. It is brown in the upper part where stained by organic solutions from the topsoil, and gray below.

Numerous small and a few fairly large areas of this soil are scattered throughout the uplands, mostly on or around the edges of the Ainsworth and Long Pine tables in the northeastern part. The largest area, comprising about 1,200 acres, is south of Dutch Creek in the western part of Pine Glen Precinct. The relief ranges from nearly level to gently rolling. Surface drainageways are absent or poorly developed because nearly all of the precipitation is absorbed by the soil.

Thurman loamy sand is not droughty, and were it not for the unstable character of its topsoil when cultivated, it probably would be as productive of crops that can adapt themselves to sandy conditions as many of the upland soils having considerably finer textured surface layers. Only about 30 percent of it is used for cultivated crops. Corn is the principal crop, and some rye and sweetclover, but practically no oats, wheat, or alfalfa, are grown. In fields that are partly protected from wind erosion by the surrounding relief, corn gives larger net returns on this soil than does native grass. In dry seasons the soil in these fields produces higher acre yields of corn than those obtained on the silty Holdrege soils. Over a period of years, however, all cultivated crops yield less on this soil, even in the most protected situations, than they do on the finer textured soils of the uplands. The average acre yield of corn is about 7½ bushels, of rye about 4 bushels, and of sweetclover about three-fifths of a ton of hay in protected and well-managed fields. If no natural or artificial protection against wind erosion is provided, the soil rapidly loses its organic

matter and cannot be used profitably for cultivated crops more than a few seasons.

The greater part of this soil is still in the virgin state. On each quarter section the native grasses will support 20 cattle during the summer grazing season or, if cut for hay, will yield about 80 tons.

Ewing loamy fine sand.—Ewing loamy fine sand differs from Ewing fine sandy loam mainly in having a looser and more sandy topsoil. It has the same general surface features, drainage conditions, and distribution as that soil but is not so extensive. The topsoil, which averages about 12 inches in thickness, is very dark grayish-brown incoherent loamy fine sand containing, in places, a small quantity of fine gravel. It gives way abruptly downward to a 15-inch layer of moderately compact grayish-brown clay loam which retards downward loss of moisture through seepage, but it is not compact enough greatly to restrict aeration or to prevent free root development. The material in this layer is slightly darker in the upper part than in the lower part. It rests on incoherent gray sand or sand and gravel, which continues downward with little change to a depth of many feet. In most places the material throughout the entire soil profile is neutral, but here and there the moderately compact clay layer contains a noticeable quantity of lime.

One of the largest areas of this soil covers about 200 acres west of Ainsworth. Other bodies of about the same size are north and south of Cedar Creek in Johnstown Precinct. The numerous remaining areas are much smaller, many of them less than 80 acres each.

Ewing loamy fine sand has high water-holding capacity and is well supplied with plant nutrients. A part of it is underlain by ground water within reach of deep-rooted crops. Were it not for the incoherent nature of its topsoil, which drifts severely under tillage during prolonged dry spells, the soil would be admirably suited for certain cultivated crops. Only about 30 percent of the land, including areas where the surrounding relief affords some protection from blowing, is farmed. As on all cultivated soils in the county, corn is the leading crop. Some rye and sweetclover are grown. Acre yields of all crops are considerably lower than those obtained on the finer textured soils of the upland, except during dry years, when yields on Ewing loamy fine sand generally exceed those on the heavier soils. Over a period of years all the cultivated crops produce a little more on this soil than on Thurman loamy sand. The greater part of the soil remains with its native grass cover and is used for pasture and hay land, for which it has a slightly higher value than Thurman loamy sand.

O'Neill loamy fine sand, upland phase.—O'Neill loamy fine sand, upland phase, resembles the corresponding phase of O'Neill fine sandy loam and has about the same general distribution, relief, and mode of occurrence, but it has a more sandy and less coherent topsoil. It has developed on mixtures of sand and gravel, which were deposited mostly as outwash from the west when glaciers in eastern Nebraska were blocking eastward-flowing streams.

The 9-inch topsoil consists largely of fine sand. It contains enough organic matter to give it a loamy texture and a dark grayish-brown or very dark grayish-brown color. It is stable in its virgin state, but

25073—38——4

is subject to considerable blowing in cultivated fields, especially in places where there is little protection from the wind. The upper part of the subsoil differs from the overlying layer only in its slightly lighter color. It merges, within a depth of 18 inches, into incoherent light-brown or gray mixed sand and gravel.

Many small areas of this soil are on or around the margins of the Ainsworth table in the north-central and northeastern parts of the county. The largest two cover a little more than 320 acres each. They lie west of Long Pine and southeast of Johnstown. Most of the areas are less than 160 acres in size.

Only a few patches around the upper edges of valley slopes are subject to destructive water erosion, and here all or nearly all of the topsoil and upper subsoil layers have been removed, exposing the coarse gravelly lower subsoil layer and substratum. Owing to their small extent, these eroded areas are not shown separately on the soil map.

This soil is low in lime throughout. Although the topsoil and upper subsoil layers retain moisture well, the lower subsoil layer and substratum have low water-holding capacity, and the soil as a whole is droughty.

Corn yields fairly well in seasons of normal or high precipitation, but in dry, windy seasons this crop is greatly impaired by the shifting topsoil and by lack of moisture in the underlying sand and gravel. Year in and year out corn will not produce more than 8 bushels an acre. Other cultivated crops do not do so well as corn and are seldom grown.

About 80 percent of the land remains in native pasture and hay land. The grasses on it will support a cow and calf on each 9 acres during the grazing season or, when cut for hay, will yield about a ton on each 2¾ acres.

Valentine loamy fine sand.—Valentine loamy fine sand is similar to Valentine fine sand which is classed with the miscellaneous soils and land types, but its topsoil contains a somewhat finer sand and is slightly darker and thicker than the corresponding layer of that soil. The topsoil, which nowhere exceeds 6 inches in thickness, is mainly fine sand, but it contains a small quantity of organic matter that gives it a loamy texture and a dark grayish-brown color. The material in the rest of the profile is gray incoherent fine sand or medium sand, which continues of uniform color and texture to a depth of many feet. Lime is not noticeable throughout the soil, but vegetation does not indicate any deficiency in lime.

Small areas of Valentine loamy fine sand are closely associated with larger areas of Valentine fine sand and dune sand throughout the sandy uplands, mostly in dry sandy valleys. The areas are numerous and range in size from a few acres to about a square mile. Most of them are elongated in shape.

The relief ranges from nearly level to very gently undulating. Surface drainage is not established because all the precipitation is rapidly absorbed by the soil material.

A higher content of organic matter in its surface layer makes Valentine loamy fine sand a little more stable than Valentine fine sand, and this feature has prompted some farmers to use the former soil for the production of feed crops, chiefly corn and rye. Fair yields are obtained during the first 2 or 3 years. After the grass roots decay,

insufficient binder remains to maintain the stability of the topsoil, and most of the cultivated areas are soon reduced to areas of gray "blow sand" having no value even for pasture until the native grasses are reestablished. Nevertheless, recently broken fields annually occupy about 15 percent of this soil. In them the average acre yields of corn and rye during the first 2 years are about 7 and 4 bushels, respectively. In a few fields so situated that the surrounding relief affords some protection from the wind, the soil may maintain similar yields for several years.

The greater part of the soil still supports native grasses and is used for grazing land and the production of hay. The grass cover is considerably heavier and has a higher grazing and hay value per unit of area than that on Valentine fine sand. In average years the grasses on each 8 acres will support a cow and calf during the summer grazing season or, when cut for hay, will yield about 3 tons. This soil and the more extensive Valentine fine sand comprise the greater part of the wild-hay land in the county.

VARIABLY DRAINED SOILS OF THE ALLUVIAL LANDS

The soils in this group are used mainly for production of corn, alfalfa, and wild hay but to some extent for small grains. The crop on any particular soil or part thereof, however, depends on local moisture conditions. The group includes the Sarpy, Cass, and Lamoure soils, all which consist mainly of comparatively recent alluvium in the bottom lands along streams. The Sarpy and Cass soils have developed on sands or mixtures of sand and gravel, whereas the Lamoure soil has formed on silty or clayey deposits. All except the Sarpy soil, which is the most recent in origin, have accumulated an abundance of organic matter and have deep dark topsoils.

Surface drainage is better than might be expected from the low positions of these soils, but occasional overflows sometimes damage cultivated crops. The water table is almost constantly within a depth of 7 feet from the surface. In seasons of abundant precipitation it rises, in some places, to or near the surface. Thus, it may be seen, the drainage conditions make the yields of cultivated crops uncertain over a considerable part of these soils.

The Sarpy soil, which ordinarily occupies the lowest positions and which is the most deficient in organic matter, is used mainly for native hay and pasture land. About 40 percent of the combined area of the Cass and Lamoure soils is devoted to corn and alfalfa in the proportion of about 15 acres of the former to 1 of the latter. In situations where the moisture supply is not excessive, these soils return higher yields of corn than can be obtained on any soil throughout the uplands. The yields of alfalfa are equaled only by those obtained on Hall very fine sandy loam. Small grains are grown only in a few widely scattered fields. Native grasses grow more luxuriantly on all soils of this group than on those of any other group, with the possible exception of some soils occupying poorly drained depressions throughout the sand hills.

None of these soils is deficient in lime, so far as crop needs are concerned. The Sarpy soil contains only a small quantity of this material, whereas in the Lamoure soils it is abundant.

Sarpy fine sand.—The topsoil of Sarpy fine sand ranges from 2 to 5 inches in thickness and consists mainly of fine sand or medium sand, the fine sand predominating. Here and there the content of organic matter is sufficient to impart a loamy texture, but the topsoil everywhere is extremely incoherent. In most places it contains only enough organic matter to give it a grayish-brown color. The material in the rest of the soil profile is light grayish-brown incoherent sand of various grades, together with a few small gravel. The coarser material becomes more abundant with depth.

Numerous small bodies and narrow elongated strips of this soil occur on the bottom lands along Niobrara River and a few of its larger tributaries, including Plum, Bone, and Long Pine Creeks. Most of the soil is adjacent to the channel and lies less than 4 feet above the normal level of the streams. Few of the bodies or strips exceed 100 acres in size, and their combined area is small. This soil has developed from recently deposited sands that have not yet accumulated much organic matter. At places it resembles riverwash, but it is more stable and is not so greatly influenced by slight rises in the streams.

The relief is nearly level except where it is modified by old and recent stream channels, slight elevations, and shallow depressions. All the soil is inundated occasionally but, with the exception of small depressions, water drains off or is absorbed within a few hours after the streams subside. The water table nearly everywhere is within a depth of 6 feet and in some places is much nearer the surface. In wet seasons it rises sufficiently to produce marshy areas in some of the lower situations.

Less than 15 percent of this soil is used for the growing of cultivated crops, chiefly corn. Most of the rest is used for native hay land, although a rather large proportion supports a growth, ranging from scattered to dense, of willow and cottonwood trees and is included in pasture. Although the organic-matter content of this soil is very low, the moisture supply is abundant, and corn yields about 10 bushels an acre on the cultivated areas in most years. The native grasses will yield about one-half ton of hay an acre or will support a cow or steer on about 8 acres during the summer grazing season.

Cass loam.—The topsoil of Cass loam is about 11 inches thick, contains an abundance of thoroughly decomposed grass remains, is friable throughout, and is very dark grayish brown or almost black. Its texture ranges from loam to silt loam, the former predominating. Below this layer is a 5- or 6-inch layer of slightly lighter colored and loosely coherent loamy fine sand. The material throughout the rest of the profile is incoherent gray sand in which rusty-brown streaks, splotches, and spots are numerous. In most places the sand is saturated with water below a depth of 4 feet. The entire soil profile is slightly limy.

This is the least extensive and the finest textured Cass soil in the county. Small widely scattered areas occupy the first bottoms of streams in both the hard-land and sand-hill areas and in valleylike positions around the heads of surface and subsurface drainageways in the sand hills. One of the largest areas is southwest of Ainsworth, and slightly smaller areas are northeast of Marys and north

of Paramount Valley. The rest of the bodies are smaller, and the total extent of this soil is not large.

The relief is nearly level, modified in a few places by slight elevations, shallow depressions, and active and abandoned stream channels. Even in dry years the surface of this soil is only a few feet above the permanent water table. In wet seasons the ground water rises sufficiently to produce marshy areas in some of the lower situations, but elsewhere water remains on the surface of the ground for only a few hours and then only after unusually heavy rains.

Over the greater part of this soil the water table is too high during wet periods to allow cultivation of crops. All except about 20 percent of the soil remains with its native grass cover and is used mainly for the production of wild hay. Owing to the favorable moisture conditions, the grasses grow unusually dense and luxuriant and yield four-fifths or 1 ton of hay an acre. The native hay is rather coarse and does not have so high a feeding value as that produced on the better drained soils of the uplands and terraces, but its higher yield tends, in large measure, to offset its inferior quality. In a few areas of this soil, ranchers have sown timothy and alsike clover seed among the native grasses, thereby greatly improving the quality of the hay. A few small areas are used for grazing land. On them the native grasses will support a cow and calf on each 4 acres during the summer grazing season.

In the few cultivated areas on the higher situations, where the water table lies below a depth of 4 feet, corn yields about 25 bushels an acre. Sweetclover does well on these areas but has a tendency to spread onto the adjoining native-hay land, where it matures and becomes woody before the wild grasses are ready for cutting, thereby reducing the quality of the hay. It is seldom grown on any bottom-land soil. Alfalfa can be grown on this soil only in the best drained situations, where it yields a little over 2 tons of hay a season.

Cass fine sandy loam.—Cass fine sandy loam differs from Cass loam mainly in that it has a more sandy and slightly looser surface layer. The topsoil, however, is sufficiently stable to prevent destructive wind erosion even in cultivated fields. It consists of very dark grayish-brown mellow fine sandy loam or sandy loam, the former texture predominating. At a depth of about 10 inches it gradually gives way, through a 6- or 8-inch layer of slightly lighter colored and only moderately coherent loamy fine sand, to loose gray sand resembling that underlying Cass loam. The soil is limy in many places, particularly below a depth of 2 feet.

This is the most extensive soil on the bottom lands. Small bodies and narrow elongated strips are scattered along the flood plains of most of the flowing streams and also occur in numerous valleylike areas of various sizes and shapes along subsurface drainageways in the northern part of the sand hills. The largest areas, some of which exceed 1 square mile, are in Ainsworth and Johnstown Precincts at the head of the Bone Creek drainage system.

The relief of this soil is nearly level, except where modified by stream channels or by barely perceptible depressions and elevations so characteristic of bottom lands. Differences in elevation nowhere exceed 3 feet.

The greater part of the drainage is subterranean. Some areas situated along streams are subject to overflow during periods of high water, but none of them remains inundated more than a few hours after the streams subside. The water table is nearly everywhere within a depth of 6 feet. It rises in wet seasons but seldom reaches the surface of the ground, even in the lower situations.

This soil is naturally strong and fertile, but in most areas the water table periodically is too near the surface for satisfactory yields of cultivated crops. Only about 30 percent of the land, including the higher lying parts, is under cultivation. Here corn and alfalfa, grown in the proportion of about 15 acres of the former to 1 of the latter, are the chief crops, and yields are equal to, or only slightly lower than, those obtained on the better drained parts of Cass loam.

Most of the soil remains in native-hay and pasture land. The grasses are slightly less luxuriant but are finer textured and more nutritious than those on Cass loam, and the two soils have about the same value for grazing and hay land.

Cass fine sandy loam, heavy-subsoil phase.—Cass fine sandy loam, heavy-subsoil phase, includes all the Cass soils in this county in which the upper part of the subsoil contains a heavier layer than is typical of Cass soils.

The soil profile is extremely variable from place to place. The topsoil ranges from less than 6 to about 12 inches in thickness and is somewhat thinner in most places than that of the other Cass soils. Over the greater part of this soil, the topsoil consists of very dark—almost black—fine sandy loam with a high organic-matter content. In some areas the texture ranges from loamy fine sand to loam within a distance of a few paces. In places "alkali" has accumulated in sufficient quantities to destroy most of the organic matter. Here the upper part of the topsoil is gray, but the lower part is darker. In some areas the immediate surface layer is fairly dark, but the lower part of the topsoil has been leached of its organic constituents and consists of almost white incoherent sand.

The 6- to 12-inch upper subsoil layer is mainly sand, but it contains considerable silt and clay and an abundance of organic matter. This layer everywhere is more compact than the topsoil and equally as dark or darker, but its density and color vary somewhat from place to place, depending on the quantity of clay and organic matter that have been leached from the topsoil. The material in this layer is very dark—almost black—and only moderately compact where it underlies a dark topsoil, whereas it is brown and extremely dense beneath the lighter colored topsoil of the alkaline spots. The material beneath the compact layer is incoherent gray sand, spotted and streaked with rusty brown. The subsoil and, in most places, the topsoil, are limy.

This soil is closely associated with the other Cass soils, but it is less extensive than most of them. The greater part of it is developed in numerous small areas south of Ainsworth along branches leading to Bone Creek. The largest body does not exceed 900 acres. A few small areas are southwest of Johnstown along Plum Creek and its tributaries.

In common with the other Cass soils, this soil occurs in the subirrigated bottom lands along permanent, intermittent, and subsurface

drainageways, where ground water is almost constantly within 8 feet of the surface. Many of the lower areas are marshy, owing to a rising water table, especially during the spring and following heavy rainfalls.

Practically none of this land is cultivated, partly because of the proximity of the water table to the surface during spring planting time and partly because of the danger of its rising high enough to kill grain and most tame-hay crops following periods of heavy rainfall during the growing season. Except in alkaline spots where vegetation is rather sparse, the soil supports a rank growth of high moisture-requiring grasses and is used almost exclusively for the production of wild hay which yields about 1 ton an acre during average years. The hay is coarse and of a lower feeding value than that on higher lying areas where moisture is less abundant. On some ranches its quality has been greatly improved by sowing timothy and alsike clover among the native grasses.

Cass loamy fine sand.—Cass loamy fine sand has about the same type of relief and mode of distribution as Cass fine sandy loam, with which it is closely associated. The topsoil consists chiefly of loose fine sand about 10 inches thick and contains so much well-decomposed organic matter that it is very dark when dry and almost black when moist. Even under cultivation it is fairly stable against wind erosion, but this feature is owing more to the low and protected position of the soil than to the coherence of its topsoil. The subsoil is incoherent sand, of which the uppermost 4 or 5 inches are stained grayish brown or light grayish brown by organic matter washed down from the topsoil. The material in the lower part is gray and contains a few rusty-brown stains.

All this soil is on sandy bottom lands, chiefly near the northern edge of the sand hills where most of the drainage is effected through subsurface seepage down the valleys. The soil is subirrigated. The water table is within 8 feet of the surface of the ground in most places.

About 40 percent of the land occupied by this soil is devoted to cultivated crops, mainly corn. The rest, especially in places where the water table rises too high during wet seasons for the production of corn and those so situated that the surrounding terrain offers little protection against wind erosion, are used for native hay and pasture land. Yields of corn range from 15 to 25 bushels an acre and average about 17½ bushels. Small grains and alfalfa are seldom grown on this soil, mainly because of the difficulty experienced in providing a sufficiently compact and stable seedbed. The native hay in virgin areas yields about three-fourths of a ton an acre during average years. Although this yield is not quite so heavy as that obtained on either Cass loam or Cass fine sandy loam, the hay is of finer texture and better quality. When used for pasture, the wild grasses on Cass loamy fine sand will support about 8 head of cattle on each 40 acres during the summer grazing season.

Lamoure fine sandy loam.—The topsoil of Lamoure fine sandy loam, which is about 10 inches thick, is darker, on the whole, than the topsoil of any other soil in the county except possibly that in some of the basins throughout the sand hills. Its texture ranges from loam to loamy fine sand, and fine sandy loam predominates. The material

is friable throughout. The subsoil is light colored and very limy. To a depth of about 3 feet it consists chiefly of silt and clay, but it contains sufficient fine sand and medium sand to produce a gritty feel. The rest of the soil profile, including the substratum, consists of gray sand similar to that beneath the Cass soils.

Lamoure fine sandy loam occupies only 8 or 10 small bodies, with a combined area of 768 acres, on the bottom lands, mostly in the southern part of Ainsworth Precinct. The largest body, comprising about 250 acres, is south of Ainsworth on a tributary to Bone Creek.

This soil has developed on fine-textured sediments which were either derived through surface wash from adjacent elevated positions or from more distant sources as stream deposits during periods of high water. Practically all of the soil lies slightly below the general level of the surrounding bottom lands. Most of it is well drained on the surface, but ground water is nearly everywhere within 6 feet of the surface, so that the lower part of the soil profile is almost continually wet. In many places the water table rises to or near the surface of the ground during early spring and following heavy rains.

Only a few small areas of this soil, in the most elevated and best drained positions, where the water table seldom rises high enough to injure the crops seriously, are used for cultivated crops, principally corn and alfalfa. Here corn produces about 25 bushels and alfalfa about 2¼ tons an acre during most years. The greater part of the land, however, is too wet for cultivation during most of the year, and it is used for the production of native hay. Virgin areas support a luxuriant growth of water-loving grasses, with sedges and cattails in many of the lower situations. The grasses will yield slightly over a ton of hay an acre in seasons of normal or near normal precipitation. The wild hay produced on this soil is neither so nutritious nor so palatable as that obtained from better drained land, but its high yield tends, in a large measure, to offset its inferior quality. The sowing of timothy and alsike on the meadows has greatly improved the quality of the hay in places, and these crops probably could be grown profitably in almost pure stands on the greater part of this soil.

POORLY DRAINED SOILS OF DEPRESSIONS

This group includes Gannett loamy fine sand, Scott silty clay loam, and small areas where the loamy fine sand types of the Gannett and Valentine soils are so intricately mixed that it is not practical to show the distribution of each on a map of the scale used in this survey.

The Scott soil occupies small poorly drained basins scattered throughout the more nearly level and finer textured parts of the uplands, and the Gannett soil occurs in wet valleys or pockets within or near the sand hills. The Valentine soil included with this group occupies small hummocks and mounds within a few of the areas of the Gannett soil.

Aside from the Valentine soil, which consists of incoherent gray sand, the surface layer of which has been only moderately darkened by organic matter, these soils have accumulated an abundance of well-decomposed grass remains, and their topsoils are very dark. That of the Scott soil is comparatively thin and consists largely of silt and clay. It rests on a lighter colored dense clay subsoil which, in most

places, extends below a depth of 5 feet. The topsoil of the Gannett soil ordinarily is thick and consists mainly of sand, but it includes so much organic matter that it has a loamy texture and, in places, is almost entirely organic and light in weight. It rests on loose gray sand which, below a depth of 2 feet, is waterlogged most of the year. Lime is abundant in the Gannett soil, but only small quantities of it are present in the other soils.

Drainage in the Gannett and Scott soils is too poor for cultivated crops. The lower parts of most of this land are covered by ponds or marshes much of the year. The Valentine soil has sufficient natural drainage for cultivation, but it occupies such small patches within the areas of the Gannett soil that it cannot be profitably tilled. Moreover, it is so unstable when its native-grass cover is removed that only a little of it is used for cultivated crops, even in places where it is the dominant soil. An unusually luxuriant growth of native grasses covers the Gannett and Valentine soils, and they are the best soils for the production of wild hay in this section. Their agricultural importance is limited, however, by their small extent. The Scott soil is of little agricultural value.

Gannett loamy fine sand.—The topsoil of Gannett loamy fine sand is very dark, in places almost black, loamy fine sand ranging from 8 to 14 inches in thickness. It is matted with plant roots and contains large quantities of organic matter in all stages of decomposition. In the lower situations the organic constituents may become so abundant as to make the soil spongy and appreciably light in weight. The subsoil is largely loose gray sand, spotted and streaked with rusty brown because of poor drainage. A 2- to 6-inch layer of saturated bluish-gray or greenish-gray sandy clay is reached in most places at a depth ranging from 2 to 6 feet.

Numerous small areas of this soil occur in the lower parts of enclosed valleys, pockets, and swales, one of the largest of which, comprising more than 640 acres, is in the vicinity of Hughes Lake and Paramount Valley in Calamus Precinct. Few of the other areas exceed 160 acres, and most of them cover less than 100 acres each. This soil has no surface drainage outlets, and seepage water from the surrounding sand hills keeps it almost continually wet or very moist. The water table is everywhere near the surface of the ground. Marshes, ponds, or shallow lakes occur in many of the lower lying areas.

None of this soil is sufficiently drained for cultivated crops, but it supports a rank growth of high moisture requiring grasses which yield a little over 1 ton an acre during most years. The hay, although of rather inferior quality as compared to that obtained on better drained soils, is amply nutritious to carry cattle and horses through the winter. Some ranchers have sown timothy and alsike clover among the native grasses and have thereby improved the quality of the hay, with no decrease in yield. Sedges and cattails grow in the moister places.

Scott silty clay loam.—The 4- to 8-inch topsoil of Scott silty clay loam consists of heavy intractable silty clay loam. In most places it is well supplied with organic matter and is very dark, especially in the upper part, but it invariably contains some light-gray silty

material, from which excessive moisture has leached the black organic matter. In some of the deeper depressions, where leaching has been most pronounced, the lower part of the topsoil is gray. The subsoil is dense lead-gray, bluish-gray, or almost black clay which contains scattered rust-colored stains and concretions and both dark and light spots and splotches caused by poor drainage. The material in this layer is plastic when wet and extremely hard and tough when dry. It continues to a depth of about 4 feet, where it rests on incoherent sand and gravel, similar to that underlying the Holdrege soils and the sandy-substratum phases of the Marshall soils. Elsewhere in Nebraska, where the Scott soil is more extensive, the heavy clay subsoil continues to a depth of about 6 feet, where it merges with the underlying parent material—a floury loessial deposit. In Brown County, however, where the loess mantle was thinner it has all developed into the topsoil and subsoil. Excessive moisture has removed the lime from the entire soil profile but as yet has not produced an acid condition.

Numerous small bodies of this soil in shallow basinlike depressions, known as lagoons and buffalo wallows, are scattered throughout the more nearly level parts of the loess-covered uplands, mostly in Johnstown, Buffalo, and Ainsworth Precincts. None of them exceeds 15 acres, and only a few cover more than one-half acre. Most of these bodies are surrounded by the highly productive Holdrege and Marshall soils. The Scott soil, however, is too poorly drained for the production of grain and tame hay. It has no surface drainage, and accumulated storm water disappears slowly through seepage and evaporation. In addition, the dense claypan subsoil limits the storage of available moisture, and the topsoil is too thin to store enough moisture for cultivated crops, especially during prolonged dry periods. As this soil occupies only a small part of any one farm, it does not reduce seriously the value of the farm land. Nearly all of it is either included in pasture land or is regarded as waste land. The growth of weeds and annual grasses is rank during early summer, but it becomes sparse as the season advances. Therefore this soil does not have a high value even for grazing.

Valentine-Gannett complex.—Areas in several sand-hill valleys throughout the southern part of the county, in which loamy fine sand soils of the Gannett and Valentine series are so intricately mixed that separation on a map of the scale used is impractical, are designated as Valentine-Gannett complex. These areas, which range from 10 to 400 acres in size, are rather numerous in Smith Precinct, where most of them are surrounded by larger areas of the typical Valentine soils.

This complex comprises many irregularly shaped hummocks or mounds of Valentine loamy fine sand, none of which exceeds 3 feet in height or covers more than a few square rods, and an intricate network of intervening swales, most of which are less than 100 feet wide, occupied by Gannett loamy fine sand. The soil on the mounds resembles the other Valentine soils except that the sand below a depth of about 4 feet is more moist than that underlying the more elevated areas of Valentine soils. The topsoil is dark grayish-brown loamy fine sand, about 7 inches thick, containing a moderate supply of organic matter. It is very incoherent when the virgin sod is de-

stroyed. Throughout the rest of the soil profile, the material is loose gray sand. In the swales the soil profile is identical with that of typical Gannett soils. Here the topsoil layer is almost black and averages about 12 inches in thickness. It has about the same texture as the corresponding layer on the mounds but is much more coherent, owing to a higher content of organic matter. The loose gray sand subsoil is highly stained with rusty brown and is waterlogged during most of the year. The thin layer of green or blue sandy clay, which occurs in nearly all Gannett soils, is present in most places.

All the mounds are well drained, whereas the intervening swales are almost continually wet or very moist. None of the areas has surface-drainage outlets, but they all are high enough above the water table to prevent inundation, even in the lower places.

Areas of Valentine-Gannett complex are used almost exclusively for the production of native hay, the yield of which averages two-thirds of a ton an acre. The hay from the swales is coarser and less palatable than that from the mounds, but the hay from the two sources becomes mixed in harvesting operations.

MISCELLANEOUS SOILS AND LAND TYPES

This group comprises areas of miscellaneous soils and land types, which are either too sandy and unstable, too gravelly and droughty, or too steeply sloping for cultivation—dune sand, Valentine fine sand, Sparta sand, rough broken land (Holt soil material), and Boyd clay loam. The first three consist of almost pure loose gray sand from the surface downward. They differ from one another mainly in surface features and elevation. Dune sand occupies some of the highest positions and has a strongly rolling to hilly relief. It covers more than one-half of the county. Valentine sand resembles dune sand, but it is less hilly, in fact most of it is low rolling or hummocky. Sparta sand has nearly level or undulating relief. It is on terraces, whereas the rest of the soils of the group are on the uplands. None of these sands is especially droughty, but all are very unstable unless protected by a cover of vegetation.

Rough broken land includes steeply sloping and severely eroded Holt soil material along the more deeply entrenched drainageways in the northern part of the county. In these areas the soil, where developed, invariably is thin. Bedrock is exposed in many places and forms vertical cliffs on some of the valley sides.

Boyd clay loam occupies steep valley slopes along Niobrara River where erosion has exposed the heavy Pierre shale formation to weathering and incipient soil formation. This soil is very shallow and is composed largely of clay. Much of it is severely gullied.

The soils and land types belonging to this group are used mainly for grazing, although a few areas of the Valentine and Sparta soils and some of the coves and pockets within areas of dune sand and rough broken land are used for the production of wild hay. The native grasses make a rather sparse growth in comparison with that on the soils of the other groups, and they do not have so high a range-carrying capacity per unit of acreage. The land classed with this group is much greater than that of all the other groups combined and includes most of the grazing land in the county.

Dune sand.—Dune sand is the term applied to the material composing the sand hills. It is not a true soil, but in Brown County it is more extensive than all the soils combined. It covers most of the southern half of the county and occupies large areas throughout the northern half. From the surface downward this material is gray incoherent sand of fine or medium grades. A fair growth of grass covers most of the land. In most places the uppermost 2 or 3 inches of material contain some organic matter but not enough to darken the sand noticeably or to prevent drifting when the grasses are destroyed. The material is unusually retentive of moisture despite its sandy character. It contains no lime.

Dune sand has been formed mainly through disintegration of the soft sandstone formations of the region and has been deposited in its present positions by the wind. Nearly all of the silt and clay originally present in these formations was removed during the continual shifting of the dunes.

The relief is variable. Throughout the southern part of the county the sand-hill terrain is characterized by a monotonous succession of irregularly distributed hills and ridges rising from 40 to 100 feet above intervening valleys, swales, and pockets. Many hummocks of less height and numerous old and recent blow-outs give variety to the landscape. The blow-outs are cone-shaped cavities formed by the wind, and most of them are on the northern and western sides of the hills. In the northern part of the county dune sand occurs chiefly in hilly areas of various sizes and shapes surrounded by much lower lying land. Here the hills, as a rule, are more rounded, are lower, and have fewer blow-outs than those in the southern part.

Surface drainage is not established, because all precipitation falling on the ground is rapidly absorbed. There are a few streams and numerous ponds and lakes within areas occupied chiefly by dune sand, but no other surface water is on this material.

Dune sand has practically no value for cultivation. Small patches are occasionally plowed, but the sand drifts so badly that the crops usually fail. Native grasses are ruined, not only in the area disturbed but also for several rods to the leeward. At present most of the dune sand is fairly well sodded, and very little of it is subject to active wind erosion. The native vegetation includes a variety of nutritious grasses. In the spring and summer these grasses will support from 60 to 70 head of cattle on each section, but they cannot be depended on for winter grazing. When cut for hay they yield about one-fourth ton an acre. The preservation of the native-grass cover is the foundation of the only agricultural activity possible on dune sand—livestock raising. Drifting sand along old roads, cattle paths, and watering tanks demonstrates plainly the disastrous effects of destroying the native vegetation. Care also should be taken to prevent range fires which promote sand drifting.

Valentine fine sand.—Valentine fine sand ranks next in total area to dune sand, with which it is closely associated. Areas of various sizes occur throughout nearly all parts of the county, mostly in the drier valleys and pockets between hills and ridges of dune sand. In the northern part many areas are around the edges of the sand hills. In places they adjoin hard-land soils. This soil differs from dune

sand mainly in having less pronounced relief which ranges from nearly level to rolling and hummocky; but differences in elevation do not exceed 20 feet. The soil supports a somewhat heavier grass cover than dune sand, and this feature, together with the lower and more protected position of the soil, makes it more stable than that material.

The soil material, to a depth exceeding 6 feet, consists of gray incoherent lime-free sand. The material in the uppermost 2 or 3 inches contains some organic matter and, in most places, is darker than the material below. The difference in color, however, is very slight, and the content of organic matter is nowhere sufficient to prevent drifting when the native sod is destroyed.

Valentine fine sand has no surface drainage, as all the precipitation is rapidly absorbed. Considering its sandy nature it has a rather high moisture-holding capacity—about 1.3 inches per foot.[4]

This soil has little value for cultivated crops, on account of its low organic-matter content and its instability when cultivated. The greater part of it is included in pasture, although much of the land in valleys throughout the sand hills is used for the production of native hay. This soil has a slightly higher grazing and hay-producing value than dune sand.

Sparta sand.—The profile of Sparta sand is almost identical with that of Valentine sand, but the Sparta soil has developed on water-stratified sediments rather than on wind-blown deposits. The relief also is more nearly level than that of Valentine fine sand.

Sparta sand consists almost entirely of very light grayish-brown lime-free incoherent fine sand or medium sand to a depth exceeding 6 feet. The material in the topmost 2- or 3-inch layer contains barely enough organic matter to make it slightly darker than the rest of the soil.

Sparta sand is developed on light-colored sandy terraces lying from 10 to 15 feet above the flood plains on both sides of Calamus River in Calamus Precinct and on smaller similar terraces along Plum Creek. A few areas occur on an old high remnant of a nearly obscured sandy terrace south of Niobrara River in the northeastern part of the county.

The moderate grass growth, chiefly of sandgrass and needlegrass (*Stipa*), will support a cow or steer on about 9 acres during the summer grazing season. Nearly all of the land is used for grazing, although some hay is cut on the terraces along Calamus River, where the yield ranges from 13 to 15 tons on each 40 acres. None of the soil can be profitably used for cultivated crops, because of its tendency to drift when not protected by a vegetative cover.

Rough broken land (Holt soil material).—The areas classed as rough broken land (Holt soil material) occupy strips of various sizes, few of which exceed 1 mile in width, on the valley slopes of several deeply entrenched drainageways in the northern part of the county. The broadest and longest strips are those along Plum and Long Pine Creeks, where they are continuous for more than 10 miles on both sides of the streams. Most of this rough broken land slopes steeply in one direction or another, and precipitous bluffs, ranging from 10 to 50 feet in height, are numerous. Run-off is rapid nearly every-

[4] From unpublished data compiled by J. C. Russell, agronomy department, University of Nebraska.

where, and erosion is severe except in scattered coves and other small areas where the slope is comparatively gradual.

The soil everywhere is shallow and rests on soft light-colored sandstone within a depth ranging from 12 to 18 inches. It is composed largely of sand or gravel formed from the disintegrated sandstone. Except on the steepest slopes, enough organic matter has accumulated to darken slightly the immediate surface layer. Locally where run-off is not rapid, the soil material is dark grayish brown to a depth of 6 or 8 inches, but in most places it is light colored from the surface downward. As it is developed from the same parent formation that underlies the Holt soils, it is regarded as Holt soil material.

Most of this land is covered with a sparse mixed growth of western yellow (bull) pine, red cedar, bur oak, ash, and elm trees, some of which are large enough for small-dimension lumber, but they are used only for posts and firewood. The tree cover is not sufficiently dense to prevent the growth of grass, except locally, and nearly all of the land is used for grazing. In the less shaded areas and in numerous small treeless patches, the growth of grama is dense. About 70 head of cattle can be grazed on each section of this land during the summer grazing season.

Boyd clay loam.—Boyd clay loam has developed on the extremely fine textured Pierre shale formation which is the lowest exposed bedrock in the county. Most of the exposures of shale are on such steep slopes and are subject to such continual erosion that little or no soil has developed. On a few of the more gradual slopes, a shallow soil has formed. Here the topsoil is very dark grayish-brown or almost black heavy clay loam, 8 or 10 inches thick. The presence of a large quantity of decayed-grass remains accounts for the dark color. Notwithstanding its heavy texture, this soil is remarkably friable, owing partly to the manner in which the lime is distributed and partly to additions of some silt and sand washed or blown onto it from higher lying soils, which have become more or less mixed with the clay in the upper part of the profile. The subsoil is poorly developed or is absent, owing to the resistance of the underlying shale to weathering and soil formation, and the topsoil ordinarily rests directly on the unweathered or only slightly altered dark bluish-gray or light-gray shale, in which, at most places, there is an intricate network of seams and cracks filled with finely divided lime.

This is one of the least extensive soils in the county. It occupies a few narrow strips, none of which exceeds 200 acres, on the lower valley slopes along Niobrara River in Pine Glen Precinct.

Although Boyd clay loam has a higher water-holding capacity than any other soil in the county, it absorbs moisture very slowly, and only a small amount of the precipitation or of the run-off from higher land is able to penetrate it. Consequently, it remains droughty except during years of unusually high moisture supply.

Only about 10 percent of this soil, including the less steeply sloping areas where the topsoil is thickest, is devoted to cultivated crops, chiefly corn and oats, of which the yields from the better fields are 10 and 12½ bushels, respectively, in normal seasons. The uncultivated areas, including the steeper and more severely eroded slopes,

are used almost exclusively for grazing. They are coverd with a fairly dense stand of mixed short and tall grasses which will support a cow and calf on each 8 acres during the summer grazing season.

LAND USES AND AGRICULTURAL METHODS

Agricultural practices in Brown County are similar to those prevailing in other counties throughout north-central Nebraska. The land, as a whole, is better suited for grazing and for the production of native hay than for cultivated crops. During normal years over 80 percent of it is in pasture and over 10 percent in wild hay. A part of the native hay is sold for cash, but most of it is used to help carry cattle through the winter. Some hay is fed to work horses throughout the year.

The cattle are largely beef animals. Most of them are raised locally and are of high quality. Grade Herefords predominate, although some Shorthorn and Aberdeen Angus cattle are raised. Nearly all ranchers use purebred bulls, and some have purebred herds. Only a few of the beef cattle are grain-fattened, on account of the scarcity of corn. Young calves generally are fed some oats during cold periods, but most of the cattle not ready for market are fed native hay in addition to pasturage during the winter. A small quantity of grain or cottonseed cake may be added to the ration. The common practice is to run the cattle on the range the year round, feeding them hay in the winter until they are 2 or 3 years old when they are shipped to the Omaha or Sioux City markets as feeders. Many ranchers sell their spring calves in the fall to feeders who fatten the calves for baby beef. Some ship in yearling cattle for summer grazing and sell them in the fall. These animals usually gain about 200 pounds during the grazing season, May 1 to October 31. Most of the ranches will support from 40 to 60 cows with calves a section the year round.

Dairy products are not a major source of income in this county, although most farmers and ranchers keep from 5 to 10 milk cows, usually of mixed beef and dairy breeding, and the surplus cream and butter are sold locally.

Horses greatly declined in value just prior to 1932, and horse raising became of minor importance. During the last year, however, the price of horses has increased considerably, and horse raising is profitable again; in fact most of the ranchers anticipate a rapid expansion of the horse-raising industry. Nearly all of the horses are raised to maturity on grass and hay. Grain is fed only to the work animals.

Sheep raising is of minor importance. A few ranchers raise from 100 to 300 sheep annually, but the total number of these animals seldom exceeds 8,000. Losses caused by coyotes and the danger of close grazing by the sheep, with the resultant destruction of the grass cover, has curtailed sheep raising, especially in the sand hills where the stability of the sand depends mainly on the maintenance of a protective grass cover.

Hogs are raised on nearly all farms where corn or alfalfa is grown, but few of the farmers have large herds, as most of the grain is needed for cattle feed. In the sand hills where corn is

scarce, the ranchers do not produce enough pork to supply their own requirements. Most of the hogs are of Hampshire, Duroc-Jersey, or Poland China breeding. There are few purebred herds, but all the animals are of good quality.

Chickens are raised on all farms and ranches. The local demand for poultry products is good, and chicken raising receives considerable attention. The flocks range in size from 50 to several hundred birds. Plymouth Rock, Rhode Island Red, and Leghorn are the principal breeds. Some of the farmers and ranchers maintain their flocks by raising baby chicks purchased from hatcheries in the larger cities. Some ranchers annually raise several hundred turkeys for the fall and winter markets. Turkeys usually do well in the sand hills, provided they receive adequate protection from coyotes. They subsist largely on insects, although milk and grain are added to the ration.

Corn is by far the most important cultivated crop, partly because it is needed to supplement the hay and pasturage ration during the winter and to feed the work animals and partly because it can be grown profitably on more sandy soils than can most other cultivated crops. It is not so extensively grown, however, in Brown County as in the more eastern and southern counties of Nebraska where the proportion of sandy soils is less. Corn is planted between the first and middle of May, usually in furrows, with a lister. It is cultivated three or four times during the season, commonly with two-row cultivators. The crop is laid by in July, after which it receives no further attention until harvest, except the removal of the more injurious weeds by hoeing. Corn matures in September or early in October, depending on the season. Most of it is husked from the standing stalks, after which cattle and horses are pastured in the fields during the winter. On some farms, especially those on the more sandy soils, where yields of corn are rather low, the crop is cut for fodder. Early-maturing varieties of yellow or white dent corn are grown chiefly. Practically all of the seed is produced in the locality where it is to be used.

Among the grain crops, oats rank next to corn in acreage. Only a few of the soils are well suited for this crop, but it is needed to feed the work horses and young livestock. Most of the oats are early-maturing varieties, including Kherson, or strains of it, such as Nebraska No. 21, a light-colored high-yielding strain developed by the Nebraska Agricultural College. The land to be used for oats is disked generally and planted with a press drill late in March or early in April. Early seeding generally results in the highest yields. The crop matures in July and is cut with a binder or a header, depending on the length of the stems. It is later shocked or stacked for threshing. Practically all of the crop is fed on the farms where produced. During the winter cattle and horses are fed oat straw which is almost as nutritious as prairie hay. Smut, although seldom serious, sometimes reduces the yield of oats during seasons characterized by prolonged periods of rainy or cloudy weather. This disease can be prevented to a great extent by spraying the seed before planting with a solution of equal parts of formaldehyde and water.

Prior to about 1920, rye occupied a smaller acreage than wheat during most years, but as more and more of the sandy land was

brought under cultivation, rye, which does better on such land than any other grain crop except corn, gradually increased in acreage and is now grown more extensively than wheat. Rye is planted in the same manner as oats but generally in the fall instead of the spring. Fall-planted rye generally makes a good growth before heavy frosts occur. It remains dormant during the winter, resumes growth in early spring, and matures in July. The crop is harvested in the same manner as oats. Some rye is planted for temporary fall or spring pasture. Rosen is the principal variety.

Barley and wheat are grown only in a few fields on the finer textured soils. All the former and most of the latter crop are planted in the spring in the same manner as oats. Practically all of the wheat is sold, but the barley is used for feed. Turkey and Kanred are the chief varieties of wheat, and Trebi and smooth-bearded varieties, such as Comfort, are the principal varieties of barley.

The production of alfalfa is confined mainly to small scattered fields on terraces and the better drained parts of the bottom lands along Niobrara River and some of the larger creeks. The varieties grown are among the most hardy obtainable, including Common, Grimm, and Cossack, all which are resistant to winter-killing. Thorough preparation of the seedbed is important in obtaining a good stand. Early plowing, followed by sufficient disking, harrowing, and rolling to compact the soil, is practiced in most places. About 15 pounds of good seed an acre is planted, usually by broadcasting, and is covered by means of a harrow. A stand of alfalfa generally is allowed to remain as long as it yields profitably. The crop is cut two or three times during the season. Some farmers pasture hogs in the alfalfa fields during a part of the summer.

Systematic crop rotation is not practiced. Most farmers plant rye or oats at 3- or 4-year intervals on land formerly used for corn. Except throughout the bottom lands and terraces, legumes are seldom grown on the grain land. Sweetclover, which has an unusually wide adaptation, could be grown more extensively in rotation with grain, especially on the coarser textured soils. It thrives on either wet or dry soils and on soils of either sandy or clayey texture and not only adds organic matter to the soil but, in common with other legumes, fixes atmospheric nitrogen in nodules on its roots. It also is a good soil binder and is especially valuable where wind or water erosion is severe. In fact, it is practically the only cultivated crop that can be used profitably in rotation with corn on the more sandy upland soils of the county.

No commercial fertilizers are applied to the soils in this county. A large quantity of manure is produced, but it is seldom used except on some soils of the bottom lands and terraces where moisture is sufficient to insure its rapid decomposition. When applied to the grain-producing soils of the uplands, manure decomposes slowly and has a tendency to reduce yields, especially during the first year, owing to its drying effect on the soil. Considerable manure mixed with hay is applied to denuded sandy areas around farmsteads and watering tanks in the sand hills and to sandy roads and trails, in order to retard wind erosion. On rented farms and ranches most of the manure is spread on the land adjacent to the barnyard.

CLASSIFICATION OF SOIL TYPES ACCORDING TO PRODUCTIVITY

In table 6 the soils of Brown County are classified according to their estimated ability to produce the more important crops of this general region. This classification compares the inherent productivity of each soil for each of the leading crops in the county to a standard, namely 100, which is the rating given a soil that is inherently the most productive in the United States for the crop under consideration and which occupies sufficient acreage to warrant classing it as the standard soil for that crop. The rating (100) is called the base index and is the standard with which the productivity of all other soils for a particular crop is compared. Thus a soil estimated to be half as productive of a given crop as the one having the base index rating receives an index of 50. A few unusually productive soils of small total acreage may have an index above 100 for a specified crop.

TABLE 6.—*Classification of soil types in Brown County, Nebr., according to productivity*[1]

Soil type[2]	Crop-productivity index[3] for—									Principal crops or type of farming
	Corn	Oats	Wheat	Rye	Barley	Alfalfa	Sweetclover	Wild hay	Pasture	
Hall very fine sandy loam	55	55	55	55	50	50	60	60	40	General farming.
Lamoure fine sandy loam (well drained)	50	40	40	45	40	50	70	85	75	Corn and alfalfa.
Cass loam (well drained)	50	40	40	45	40	50	70	85	78	Do.
Cass fine sandy loam (well drained)	45	30	30	30	30	45	75	80	73	Do.
Holdrege loam	45	45	45	45	40	20	60	60	33	General farming.
Marshall very fine sandy loam, sandy-substratum phase.	45	45	45	45	40	20	60	60	33	Do.
Holdrege fine sandy loam	40	35	35	40	35	20	50	65	28	Do.
Marshall fine sandy loam, sandy-substratum phase.	40	35	35	40	35	20	50	65	28	Do.
Cass loamy fine sand (well drained)	35	25	25	30	25	40	65	70	48	Corn and alfalfa.
Holt fine sandy loam	30	30	30	35	30	20	40	65	26	General farming.
Ewing fine sandy loam	30	25	25	30	25	20	45	65	33	Do.
O'Neill sandy loam	30	25	25	30	25	25	45	50	30	Corn, rye, and sweetclover.
Thurman fine sandy loam	25	20	20	25	20	15	35	50	30	Do.
Boyd clay loam	20	25	25	25	25	10	35	20	19	General farming.
O'Neill fine sandy loam, upland phase	20	15	15	20	15	10	30	50	20	Corn, rye, and sweetclover.
Ewing loamy fine sand	20	15	15	20	15	15	35	55	28	Do.
Thurman loamy sand	15	10	10	15	10	10	30	50	24	Do.
O'Neill loamy fine sand, upland phase	15	10	10	15	10	10	30	35	21	Do.
Valentine loamy fine sand	10	10	10	15	10	10	25	40	21	Do.
Lamoure fine sandy loam (poorly drained).	----	----	----	----	----	----	----	110	84	Native hay and pasture.
Cass loam (poorly drained)	----	----	----	----	----	----	----	105	89	Do.
Cass fine sandy loam, heavy-subsoil phase (poorly drained).	----	----	----	----	----	----	----	100	84	Do.
Cass fine sandy loam (poorly drained)	----	----	----	----	----	----	----	100	84	Do.
Cass loamy fine sand (poorly drained)	----	----	----	----	----	----	----	75	59	Do.
Gannett loamy fine sand	----	----	----	----	----	----	----	105	65	Do.
Valentine-Gannett complex	----	----	----	----	----	----	----	65	43	Do.
Scott silty clay loam	----	----	----	----	----	----	----	50	25	Do.
Sarpy fine sand	----	----	----	----	----	----	----	50	19	Do.
Sparta sand	----	----	----	----	----	----	----	35	21	Do.
Valentine fine sand	----	----	----	----	----	----	----	35	21	Do.
Rough broken land (Holt soil material)	----	----	----	----	----	----	----	35	18	Do.
Dune sand	----	----	----	----	----	----	----	25	15	Do.

[1] This table has been compiled jointly by officials of the following organizations: Soil Survey Division, Bureau of Chemistry and Soils, and Land Use Planning Section, Farm Security Administration, U. S. Department of Agriculture; and the Conservation and Survey Division and Agricultural College, University of Nebraska.

[2] Soils are listed in approximate order of their general productivity in the county, the most productive first.

[3] Soil types inherently most productive for the specified crop in the United States are given an index 100. Only those inherently most productive soil types of significant acreage in the more widely known crop regions have been given the standard of 100. The other indexes give the approximate production in percentages of the standard.

NOTE.—No ratings on grain and tame-hay crops are given on soils that are definitely unsuited for cultivation, although some areas of these soils are farmed.

The inherent productivity indexes show the natural ability of the soil to maintain production at or near the level existing when the soil has become adjusted to tillage. These indexes are established under the assumption that the best cropping and soil-management practices are followed, excepting those that would materially modify the soil, such as the use of commercial fertilizers, residues, and manures from crops not grown on the soil; terraces; irrigation; and artificial drainage.

The soils are listed in the order of their general productivity, which is determined chiefly by their ability to produce the more important staple crops. No attempt is made to group the soils best suited for particular crops, and no consideration is given to differences in the quality of the crops.

As the soils in this county are not limed or treated with commercial fertilizers, no rating is given to indicate their response to these materials.

The factors influencing the productivity of the soils are mainly climate, soil characteristics, and relief, or lay of the land. Since long-time yields [5] furnish the best available summation of the factors contributing to soil productivity, these were among the data used in determining the inherent productivity indexes given in the table.

The rather low indexes given to most of the soils do not necessarily indicate that these soils are poorly suited for the crops grown on them. Some of the soils are among the strongest and most productive in this general region. Few of them return as high yields of any particular crop as are obtained on the standard soil for that crop, but this, in most instances, is due mainly to less favorable moisture conditions and surface features, or both, than occur in areas of the standard soil. Most soils in the county contain enough plant nutrients to insure higher yields were moisture more abundant.

In rating the soils on the bottom lands or flood plains, two index ratings are given, one applying to the better drained areas and the other to poorly drained areas. The soil map, however, does not distinguish between these areas, except in localities where drainage is so poor that a marshy condition prevails a part of each year. Such areas are indicated by the conventional marsh symbol. Elsewhere on the bottom lands the poorly drained tracts, although numerous, occupy such small patches and narrow strips that they cannot be indicated legibly on a map of the scale used in this survey. Streams occasionally overflow small local tracts on the flood plains, but no special consideration is given to these tracts, because overflow is of little importance in the agriculture of this county.

The table here presented is not based on enough factors which influence land use to warrant interpreting the ratings directly into specific land values. It is based on essentially permanent factors relating to the inherent productivity of the soils, and no consideration has been given transitory economic factors. In some instances the information on which the ratings are based is not so complete as desired, and further study may suggest changes.

[5] Data on long-time yields for specific soils were collected by the field party during and subsequent to the soil survey. Also, free use was made of unpublished estimates on average annual crop yields for the period 1923–32, supplied by the Bureau of Agricultural Economics, U. S. Department of Agriculture, and the Nebraska State Department of Agriculture, cooperating.

The following tabulation gives the more important crops of the county and the acre yield that has been set up as a standard of 100 for each crop. These yields represent long-time production averages of the inherently most productive soils of significant acreage in the United States for products of satisfactory quality and are obtained without the use of soil amendments other than those produced directly or indirectly by the soil.

	Bushels
Corn (grain)	50
Oats	50
Wheat (all kinds)	25
Rye	25
Barley	40
	Pounds
Alfalfa	9,000
Sweetclover	4,000
Wild hay	2,000
	Cow-acre-days per year[6]
Pasture	100

MORPHOLOGY AND GENESIS OF SOILS

Brown County is within the Chernozem soil belt of the United States. It is so near the western edge of this belt, however, and includes so much of the sand-hill section that few of its soils have both of the two outstanding features common to normal Chernozems, namely, very dark brown topsoils and a zone of lime enrichment in the subsoils, and in none of the soils are they well developed. The distinguishing characteristics of most soils are the result more of local parent materials and drainage conditions than of the broader environmental influences of climate and vegetation.

All the soils, except those that are severely eroded or are composed mainly of recent stream deposits, have developed under a grassy vegetation. On the finer textured soils of the uplands and terraces the chief grasses are *Stipa comata*, *Bouteloua gracilis*, and *Buchloë dactyloides*, with *Koeleria cristata*, *Agropyron smithii*, and *Andropogon scoparius* as secondary species. On the sandy uplands *Calamovilfa longifolia*, *Andropogon hallii*, and *Bouteloua hirsuta* dominate, with *Redfeldia flexuosa* and *Muhlenbergia pungens* in scattered societies, especially in blow-outs and in heavily grazed areas. On the subirrigated flood plains and in moist sand-hill valleys *Andropogon furcatus*, *Sorghastrum nutans*, *Panicum virgatum*, and *Spartina pectinata* are abundant, and *Carex stricta*, *Typha latifolia*, and *Scirpus validus*, in the order named, extend from the tall-grass associations into the marshes and lakes.

Throughout most of the county the parent soil material either consists largely of unstable quartzitic sand that is extremely resistant to weathering and the formation of soil or occupies such steeply sloping or poorly drained situations that soil development has been retarded greatly. The only soils that appear to have attained a profile ap-

[6] "Cow-acre-days" is a term used to express the carrying capacity of pasture land. As used here, it is the product of the number of animal units carried per acre multiplied by the number of days the animals are grazed without injury to the pasture. For example, a soil type able to support 1 animal unit per acre for 360 days of the year rates 360, whereas another type able to support 1 animal unit per 2 acres for 180 days of the year rates 90. Again, if 4 acres of pasture support 1 animal unit for 100 days the rating is 25.

proaching maturity are those on the more nearly level parts of the tablelands, chiefly in Pine, Buffalo, Ainsworth, and Johnstown Precincts, and on some of the older terraces in the larger stream valleys. In these areas, which cover probably less than 5 percent of the county, the soils have formed on parent materials ranging in texture from sand to silt. They have developed under good drainage, however, in the absence of alkali, destructive wind erosion, or other influences of a strictly local nature, and have reached a more advanced stage of development, consistent with the regional climate and vegetation, than any other soil in the county. Their surface layers are dark grayish brown or very dark grayish brown, and the dark color extends to a depth ranging from 10 to 16 inches. Soils developed on sandy materials have been leached almost entirely of their readily soluble salts, whereas those developed on silty deposits have fairly well developed subsoil zones of lime enrichment, wherever the silty material extends to or near the average depth of penetration by moisture.

The following description of a profile of Holdrege loam, observed on the smooth loess-mantled uplands in sec. 18, T. 30 N., R. 22 W., may be regarded as typical of the more nearly mature silty soils:

1. 0 to 1½ inches, dark grayish-brown friable single-grain very fine sandy loam which is mulchlike when dry.
2. 1½ to 4 inches, very dark grayish-brown friable loam or silt loam, with an ill-defined laminated or platy structure. Crushing a lump of this material produces no noticeable change in color.
3. 4 to 15 inches, dark grayish-brown friable silt loam with a fine-cloddy structure and a weakly expressed columnar form. The lumps are soft, small, and irregularly shaped. They can be easily crushed between the fingers and thumb, and the powdered material is slightly lighter in color than the surfaces of the structural aggregates.
4. 15 to 32 inches, dark grayish-brown friable heavy silt loam or light silty clay loam. This layer is heavier than any above or below, but its increased density is scarcely noticeable except by close comparison. It has a fine-cloddy structure and a well-developed columnar form. A lump of it is little or no lighter in color than one from the layer above, but the crushed material is considerably lighter colored than that in any overlying horizon.
5. 32 to 46 inches, grayish-brown friable and cloddy, but otherwise structureless, silt loam. The lumps, which range widely in size, are easily reduced to powder form, although crushing produces little change in color. The material is markedly columnar.
6. 46 to 65 inches, very light grayish-brown or grayish-yellow floury silt containing considerable lime, chiefly in finely divided form thoroughly mixed with the silt. This is the zone of carbonate accumulation. It is slightly altered parent loess, into which the carbonates have been leached from the overlying horizons. The loessial material is columnar but otherwise structureless.
7. 65 to 96 inches, an incoherent mixture of gray sand and gravel. This material does not enter into the solum, all which is developed in the overlying loess deposit.

The transition between all the horizons of the profile is gradual in color, texture, and consistence, but the contact between the base of the zone of carbonate enrichment and the sand-and-gravel substratum is very sharp. The topmost two layers of the soil profile are thickly matted with grass roots, and the topmost three layers contain an abundance of organic matter, which accounts for their dark color. In the fourth layer, enough organic material is present to give the undisturbed soil a very dark appearance, but practically

all of it is in filmlike coatings on the surfaces of the structural agregates. When the agregates are crushed the powdered soil is rather light colored. The film becomes progressively thinner with depth, and the lower part of the profile is practically devoid of organic matter. All horizons beneath the third contain scattered worm casts and tortuous rod-shaped borings ranging from one-eighth to one-fourth inch in diameter. The borings represent old cavities formed by roots, worms, and insects, that have been filled subsequently with either lighter or darker material than that in the surrounding matrix.

The Hall soil on the well-drained silty terraces of this county has a profile that is almost identical with the one described, except for a slight difference in texture of the topsoil.

The sandy-substratum phases of the Marshall soils are associated with Holdrege loam on the thinly loess mantled uplands, where the loessial deposit is slightly more sandy, porous, or thinner than is typical. Here downward-moving waters have everywhere penetrated through the loess mantle and have removed the carbonates. Therefore these phases of the Marshall soils have been unable to develop a zone of lime enrichment in their subsoils. Otherwise they closely resemble the Holdrege soils.

In the sandy parts of the county the only soils that have attained normal or near normal development consistent with the regional environment are those of the Thurman and the O'Neill series, the corresponding types of which are almost identical in profile features. The soils of the first-named series are on nearly level or gently rolling uplands where they have developed from sands that were transported mainly from areas to the west during Pleistocene time and were deposited on outwash plains along the western edge of the Kansan glacier.

The O'Neill soils are on sandy terraces of smooth or slightly hummocky relief. Although the Thurman and O'Neill soils consist largely of sand, they apparently have remained for long periods in their present positions undisturbed by destructive wind or water erosion. They have accumulated an abundance of organic matter and have developed very dark grayish-brown topsoils, ranging from 8 to 14 inches in thickness. The upper subsoil layers are brown and well oxidized and rest on loose gray sand which extends downward for many feet. Owing to their porous character, these soils have been unable to develop a zone of carbonate enrichment in their subsoils.

The rest of the soils owe their distinguishing features mainly to the character of the local drainage and parent soil materials. Except in poorly drained basins, none of the soils in the sand-hill areas has accumulated much organic matter. Nearly all of them are lime free, light colored, incoherent, and uniformly sandy throughout, although several have a surface layer that is slightly darker than the subsoil layer. Dune sand, which is not classed as a soil, contains practically no organic material aside from that in living or recently living grass roots.

Most of the soils on the flood plains along streams and in wet pockets and swales throughout the sand hills have almost black and,

in many places, thick topsoils. Many of them also contain an abundance of lime. No zone of lime enrichment or other evidence of normal development, however, is present in their subsoils which invariably are more or less splotched, streaked, and spotted with rusty brown and gray, owing to imperfect drainage. In most of the poorly drained valleys, pockets, and swales throughout the sand hills, the soils are characterized by a glei layer at a depth ranging from 4 to 6 feet.

Areas widely scattered on the sandy flood plains and in subirrigated sand-hill valleys, ranging from 1 to 20 square rods in size, have soils which closely resemble the Solonetz soils and may represent the true Solonetz type of soil development. The genetic history of these soils, however, has not been traced, and no positive correlation has been made. In these areas, nearly all of which lie within larger areas of Cass soils, the topsoil is almost black structureless fine sandy loam or loamy fine sand, ranging from 6 to 10 inches in thickness. The second horizon is composed of thoroughly leached and almost white fine sand or very fine sand. It seems to have developed largely at the expense of an underlying claypan, with which it varies inversely in thickness. In most places the light-colored sand layer is less than 3 inches thick, but in some areas it is 10 or 12 inches thick. The third horizon, or claypan, may or may not be continuous. Where present it consists of brown extremely dense sandy clay or clayey sand, ranging from less than 1 inch to about 2 feet in thickness. The general appearance of this horizon varies greatly. In some places it is simply a layer of massive sandy clay having comparatively smooth upper and lower surfaces and an abundance of readily soluble salts, most of which are concentrated in the lower half. Elsewhere the claypan is columnar in the upper part and massive with a high salt concentration in the lower part. The tops of the columns are light colored and well rounded, and the layer, as a whole, has the appearance of a normally developed columnar Solonetz. The only part of the profile to the base of the claypan, however, that will not react vigorously with hydrochloric acid is the light-colored sand immediately beneath the topsoil. In a few places the claypan is made up of numerous ellipsoidal blocks having longer horizontal than vertical dimensions and well-rounded edges and corners. Many of the larger ones are more than 2 feet long. Some of the smaller ones are almost round. The blocks are separated by a network of seams and cracks, ranging from one-half to 3 inches in width, filled with light-colored sand from the overlying layer. Most of the blocks rest on incoherent rust-stained sand similar to that beneath the surrounding Cass soil, but in some places they are entirely surrounded by the lighter colored leached sand. Within the areas characterized by the blocky claypan are scattered patches occupying from 8 to 10 square feet, in which the compact material, if originally present, has been replaced entirely by the leached sand which extends from the base of the topsoil to the underlying rust-stained sand. Owing to their local occurrence and small extent the Solonetzlike areas are not shown separately on the accompanying soil map.

Mechanical analyses of several soil profiles are given in table 7.

TABLE 7.—*Mechanical analyses of several soil profiles in Brown County, Nebr.*

Soil type and sample number	Depth	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
Holt fine sandy loam:	*Inches*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
378314	0–12	0.2	4.0	13.5	35.6	17.7	17.0	12.0
378315	12–21	.4	4.0	13.8	36.4	19.1	11.3	15.0
378316	21–34	7.4	10.8	10.2	19.1	16.2	15.5	20.8
378317	34–50+	6.3	11.7	21.2	33.0	15.4	7.6	4.8
Ewing fine sandy loam:								
378305	0– 4	.3	3.2	11.5	39.0	18.3	17.8	9.9
378306	4–11	.3	3.0	7.9	27.1	21.4	25.2	15.1
378307	11–29	0	.5	1.2	5.7	20.3	34.1	38.2
378308	29–33	.1	.4	.8	4.5	22.8	41.1	30.4
378309	33–39	.1	.7	1.9	6.3	22.8	41.3	26.8
378310	39+	1.7	9.5	27.5	50.1	6.3	1.2	3.6
Holdrege loam:								
378349	0– 2	.8	2.9	2.4	4.0	23.0	47.7	19.1
378350	2– 4½	.6	3.0	2.4	4.2	21.9	48.4	19.6
378351	4½–20	1.4	5.7	3.7	4.3	19.5	42.8	22.7
378352	20–34	.3	1.6	1.2	2.9	15.7	44.4	33.9
378353	34–42	.2	.5	.3	2.2	21.2	43.9	31.8
378354	42–62	0	.2	.2	1.9	21.1	48.0	28.7
378355	62+	8.4	27.0	20.1	17.9	9.0	10.3	7.3
Valentine fine sand:								
378375	0– 5	0	3.1	13.1	57.1	14.0	7.5	5.2
378376	5–12	.1	4.2	17.2	65.1	9.3	.2	3.9
378377	12–60+	0	2.9	13.3	64.0	15.7	.6	3.5

SUMMARY

Brown County is in north-central Nebraska. It is rectangular and comprises 1,215 square miles, or 777,600 acres. The northern boundary follows the somewhat irregular course of Niobrara River.

The county is part of a former nearly level to rolling constructional plain on which stream dissection and wind erosion have produced considerable relief. It comprises all or parts of four rather well-defined physiographic divisions: Niobrara Valley, Ainsworth table, Long Pine table, and the sand-hill section.

The county, as a whole, is well drained, although the water table is near or above the surface of the ground in some of the sand-hill valleys and pockets and in spots on the valley floors along some of the drainageways.

The elevation ranges from about 2,450 feet to 2,620 feet above sea level. The land slopes gradually to the south and east.

The climate is continental, with a mean annual temperature of 47.7° F. and a precipitation of 25.23 inches. The rainfall generally is well distributed in early summer, but dry spells are common during July and August.

All the county is within or adjacent to the sand-hill section of Nebraska, where the stability and utilization of the more extensive soils depends largely on the maintenance of their native-grass cover. Only the finer textured soils and those which are protected from blowing by a favorable relief or moisture supply can be used economically for the production of cultivated crops.

The preponderance of soils suited mainly for grazing land and the production of wild hay has necessitated dependence on the raising of livestock, chiefly cattle, for revenue since the earliest settlements were made. According to the Nebraska agricultural statistics, only about 9 percent of the land in the county was under cultivation in 1929, and the rest was used chiefly for native-pasture and hay land.

In the cultivated areas, mainly on the Ainsworth and Long Pine tables, most of the crops grown are those that can be used for feed to supplement the livestock ration of native hay during the winter. Corn occupies most of the tilled land, followed by oats, rye, timothy and clover mixed, alfalfa, and sweetclover, ranking in acreage in about the order named during most years.

The most extensive fine-textured soils are the Holdrege and Marshall, which occur only on the tablelands, and Hall very fine sandy loam which is on rather silty terraces. These soils are intensively farmed, are admirably suited for all crops common to the section, and produce most of the grain and tame hay grown in the county. They occupy, however, less than 5 percent of the total area.

Throughout the uplands and terraces are numerous areas where the soils, although composed largely of sand, have accumulated enough silt and organic matter to give their surface layers a loamy texture. In these areas, which include moderately coherent types of the Thurman, Ewing, Valentine, and O'Neill soils, the topsoil layers are darker and more stable than the corresponding layers in dune sand, Valentine fine sand, and Sparta sand of the strictly grazing land areas. In some of them the topsoils are sufficiently stable and contain enough organic and fine mineral materials to allow cultivation. This is particularly true of Thurman fine sandy loam, O'Neill sandy loam, and an upland phase of O'Neill fine sandy loam, where such crops as corn, rye, and sweetclover are grown rather extensively and return profitable yields in most years.

The rest of the moderately coherent soils have topsoils that are too loose for cultivation, unless extreme care is taken to prevent wind erosion. They include Thurman loamy sand and the loamy fine sand types of the Ewing, O'Neill, and Valentine soils. These soils are devoted mainly to the production of native hay, for which they are much better suited than are the strictly grazing land soils.

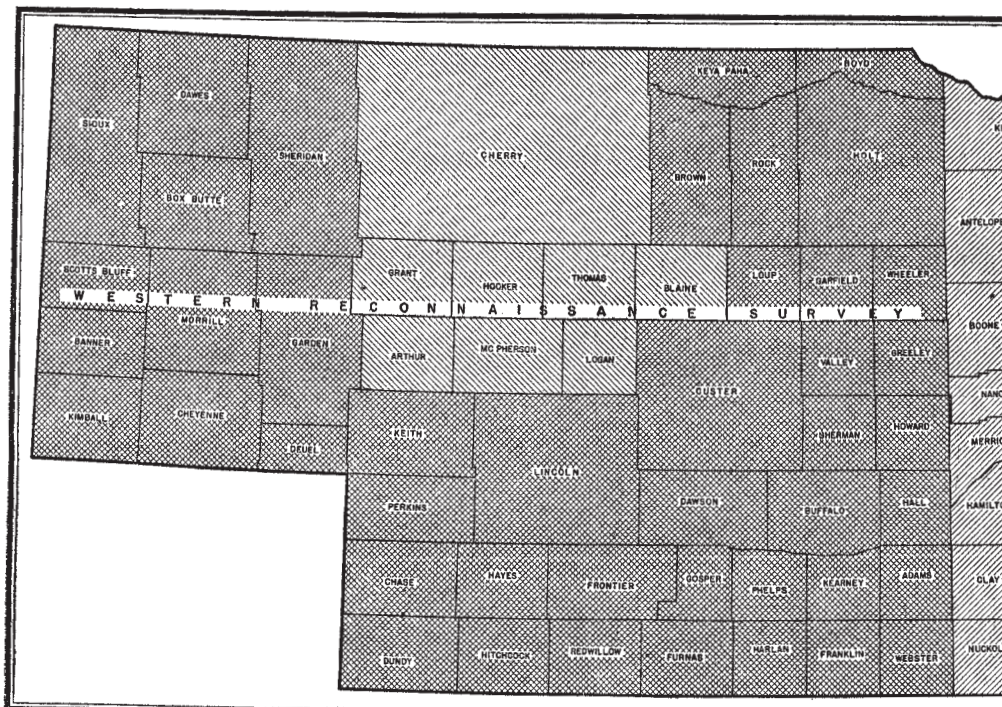
The most valuable soils in the county for the production of wild hay are the Cass, Lamoure, and Gannett. The first two named are on flood plains along streams, and the Gannett soil is in subirrigated valleys, pockets, and swales throughout the sand hills.

The most widely distributed soil material is dune sand which, together with Valentine sand, Sparta sand, rough broken land (Holt soil material), and Boyd clay loam, comprises most of the grazing land. None of these soils and land types is suited to cultivation.

All the soils contribute their products mainly to cattle raising. Some wheat is grown on the Holdrege, Marshall, and Hall soils, but during most years this crop occupies only a few small and widely scattered fields. The greater part of all crops, except wheat, is fed to beef cattle which are the chief source of revenue. Most of the cattle are of Hereford breeding and are raised locally.

Authority for printing soil-survey reports in this form is carried in the Appropriation Act for the Department of Agriculture for the fiscal year ending June 30, 1933 (47 U. S. Stat., p. 612), as follows:

There shall be printed, as soon as the manuscript can be prepared with the necessary maps and illustrations to accompany it, a report on each soil area surveyed by the Bureau of Chemistry and Soils, Department of Agriculture, in the form of advance sheets bound in paper covers, of which not more than 250 copies shall be for the use of each Senator from the State and not more than 1,000 copies for the use of each Representative for the congressional district or districts in which a survey is made, the actual number to be determined on inquiry by the Secretary of Agriculture made to the aforesaid Senators and Representatives, and as many copies for the use of the Department of Agriculture as in the judgment of the Secretary of Agriculture are deemed necessary.



Areas surveyed in Nebraska shown by shading. Detailed surveys shown by northeast-southwest hatching
southeast hatching; crosshatching indicates areas covered in both

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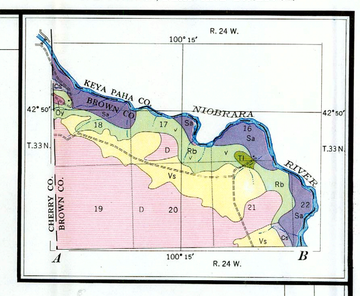
SOIL MAP
BROWN COUNTY
NEBRASKA

UNIVERSITY OF NEBRASKA
STATE SOIL SURVEY DEPARTMENT OF THE
CONSERVATION AND SURVEY DIVISION
G. E. CONDRA, DEAN AND DIRECTOR

Note: *Approximate southern edge of old Niobrara River terraces.*



LEGEND

- Boyd clay loam — By
- Marshall fine sandy loam, Sandy-substratum phase — Mt
- Cass loamy fine sand — Cs
- Marshall very fine sandy loam, Sandy-substratum phase — My
- Cass fine sandy loam — Cl
- O'Neill loamy fine sand, Upland phase — Ol
- Cl — Heavy-subsoil phase
- O'Neill sandy loam — Oy
- Cass loam — Cm
- O'Neill fine sandy loam, Upland phase — Of
- Ewing loamy fine sand — Ew
- Sarpy fine sand — Sa
- Ewing fine sandy loam — Ef
- Scott silty clay loam — Sc
- Gannett loamy fine sand — Gl
- Sparta sand — Sp
- Hall very fine sandy loam — Ha
- Thurman loamy sand — Tl
- Holdrege fine sandy loam — Ho
- Thurman fine sandy loam — Tf
- Holdrege loam — Hl
- Valentine fine sand — Vs
- Holt fine sandy loam — Hf
- Valentine loamy fine sand — Vf
- Lamoure fine sandy loam — Lf
- Valentine-Gannett complex — VG
- Dune sand — D
- Rough broken land (*Holt soil material*) — Rb

CONVENTIONAL SIGNS

CULTURE
(Printed in black)

City or Village, Roads, Buildings, Wharves, Jetties, Breakwater, Levee, Lighthouse, Fort
Secondary roads and Trails
Railroads Steam and Electric
Bridges, Ferry
R.R.crossings, Tunnel
Ford, Dam, Sawmill, Windmill
Boundary lines
School, Church, Creamery, Cemeteries
Boundary lines
Triangulation station
Boundary monument
Oil or Gas wells
U.S.Township and Section lines
Recovered corners
Forest fire station
Airway beacon
Oil or Gas tanks
Transmission line
Oil or Gas pipe line
Mine or Quarry
Rock outcrop
Made land
Soil boundaries, Stony, Gravelly and Cherty areas

RELIEF
(Printed in brown or black)

Contours
Depression contours
Prominent Hills
Mountain peaks
Sand, Wash, and Sand dunes
Bluff, Escarpment, Mine dumps

DRAINAGE
(Printed in blue)

Streams, Springs, Wells, Flowing wells
Lakes, Ponds, Intermittent lakes
Unsurveyed and intermittent streams
Waterpipe lines, Canals, Ditches, Flumes
Swamp
Salt marshes
Submerged marsh
Tidal flats

The above signs are in current use on the soil maps. Variations from this usage appear in some maps of earlier dates.

Thomas D. Rice, Inspector, District 3.
Soils surveyed by E. A. Nieschmidt, Nebraska Soil Survey, in charge, and F. A. Hayes and S. R. Bacon, U. S. Department of Agriculture.

Scale 1 inch = 1 mile
1 ½ 0 1 2 3 Miles

WILLIAMS & HEINTZ CO., WASH., D. C.

Field Operations
Bureau of Chemistry and Soils
1933